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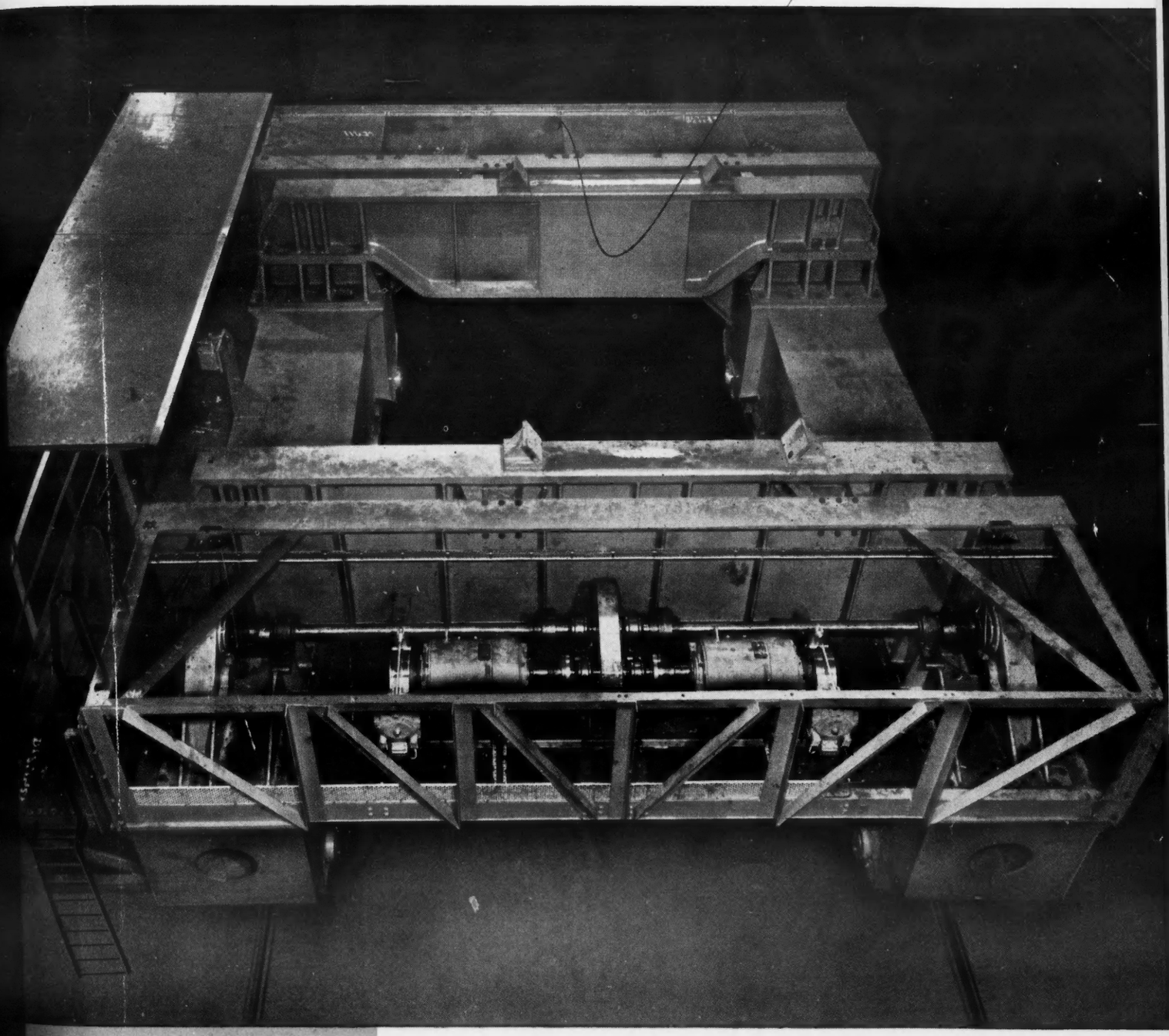

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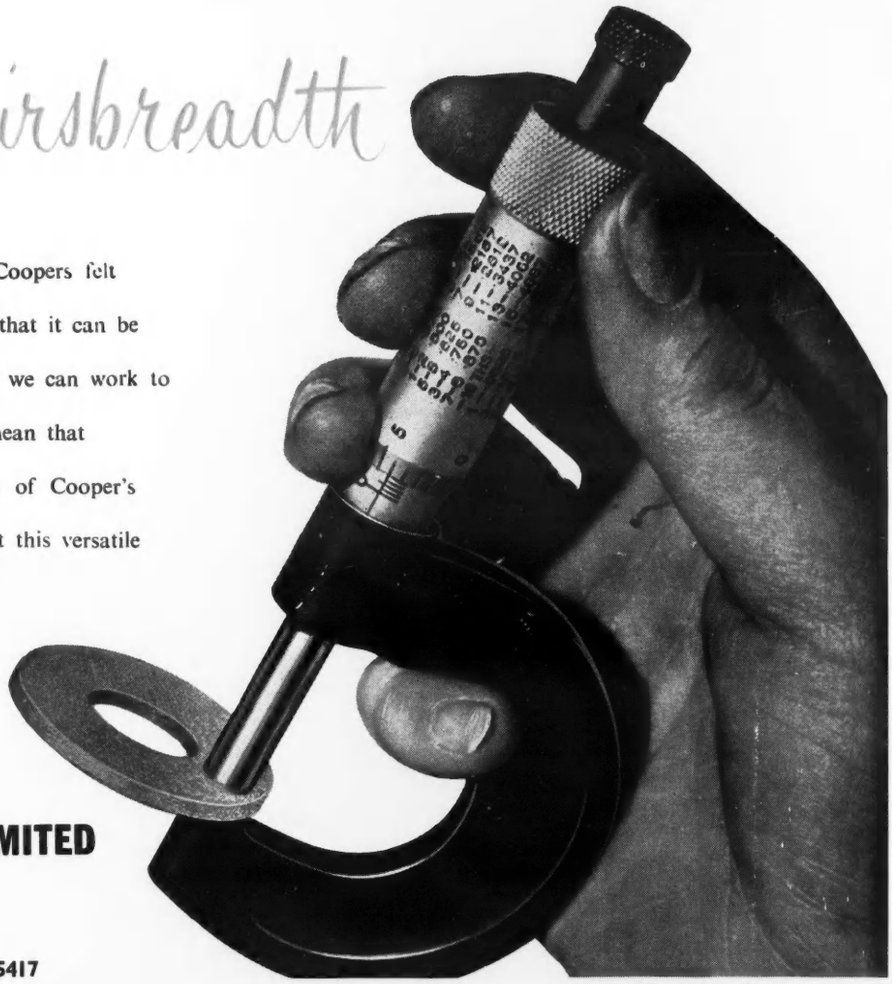

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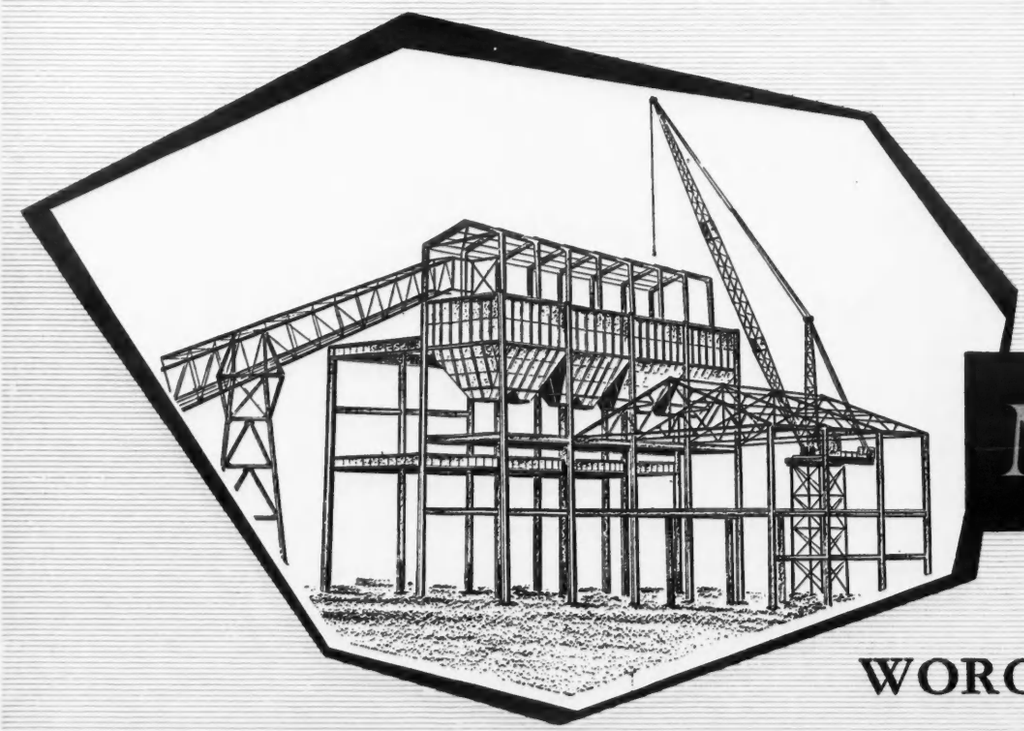

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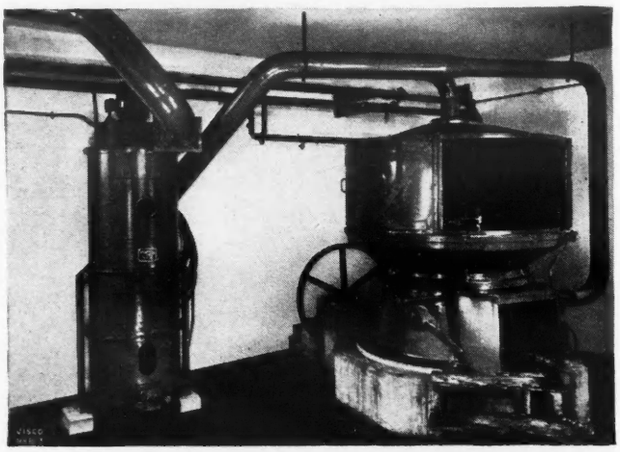

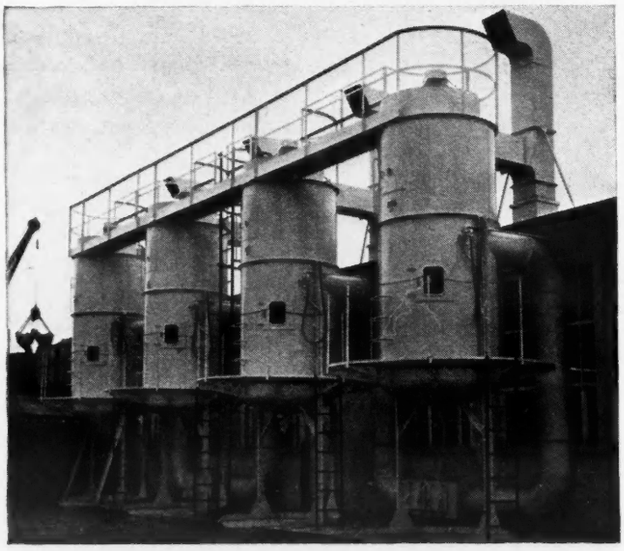

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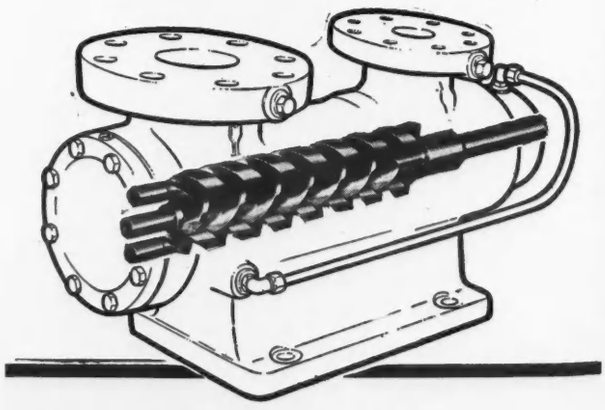

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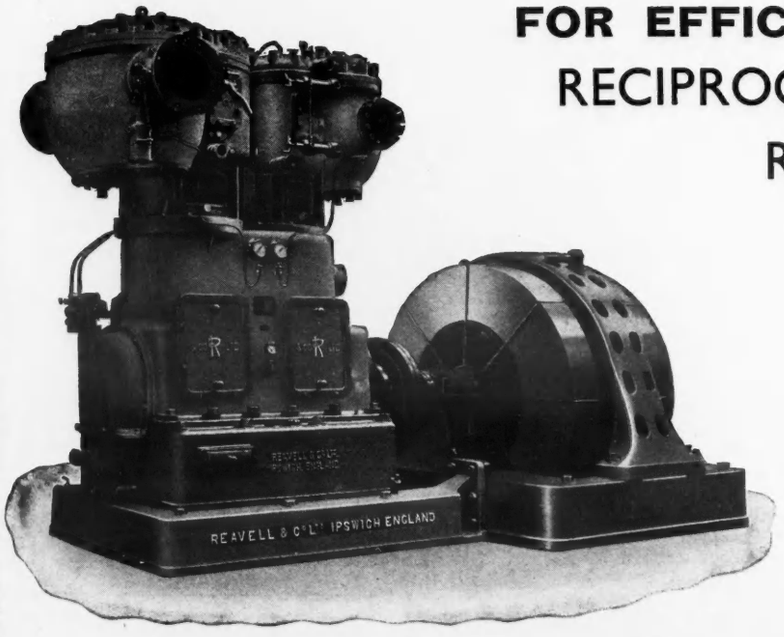

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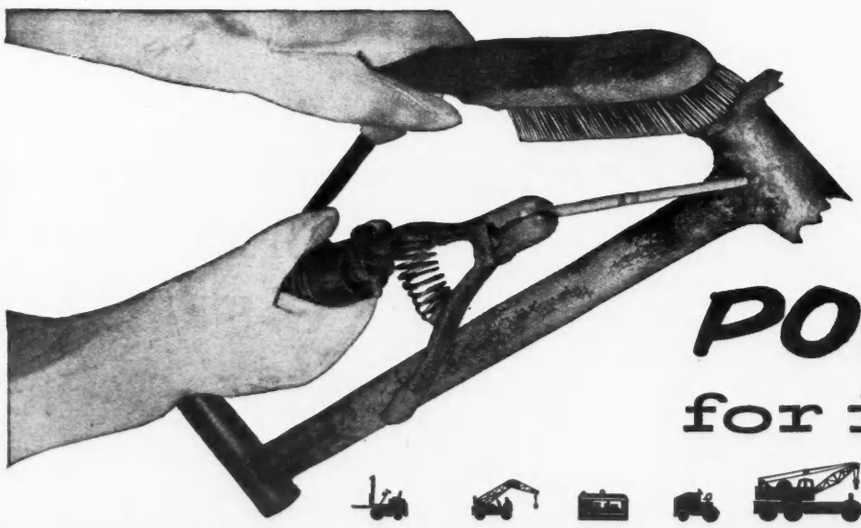

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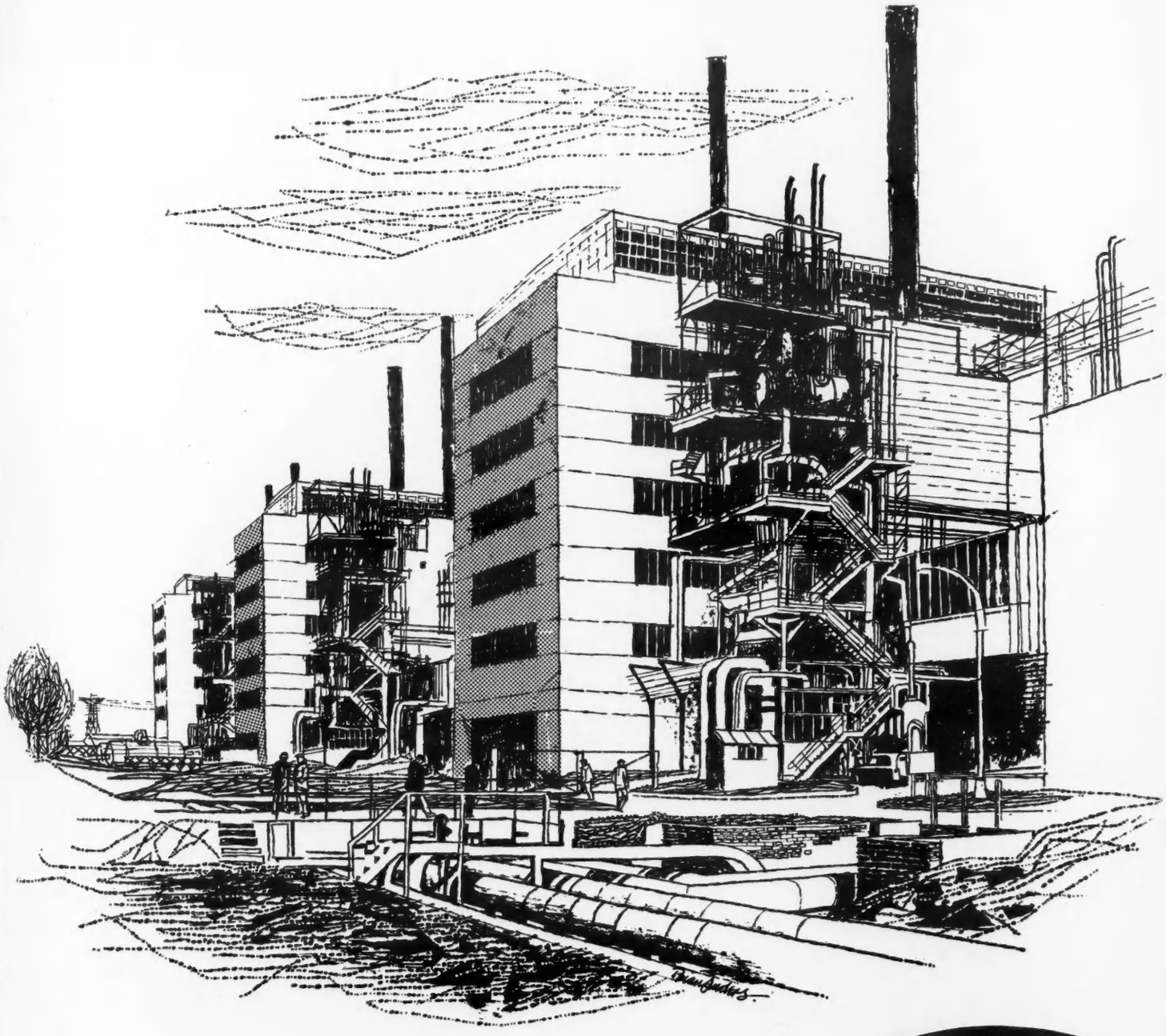

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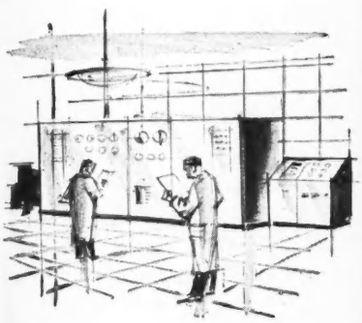

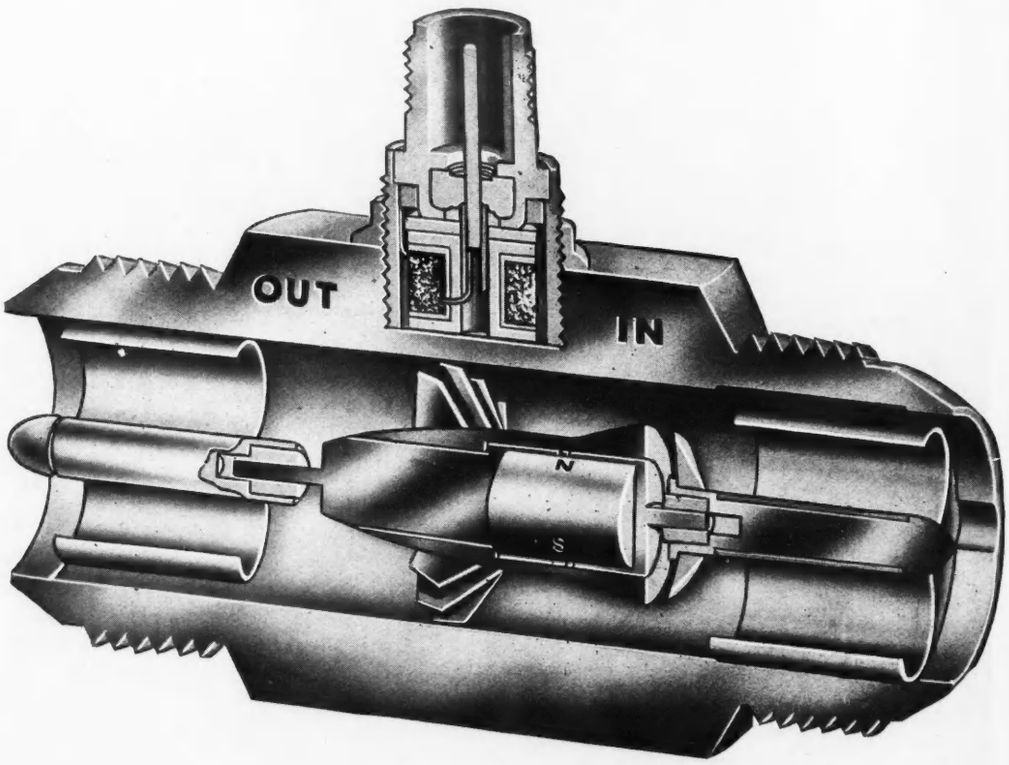

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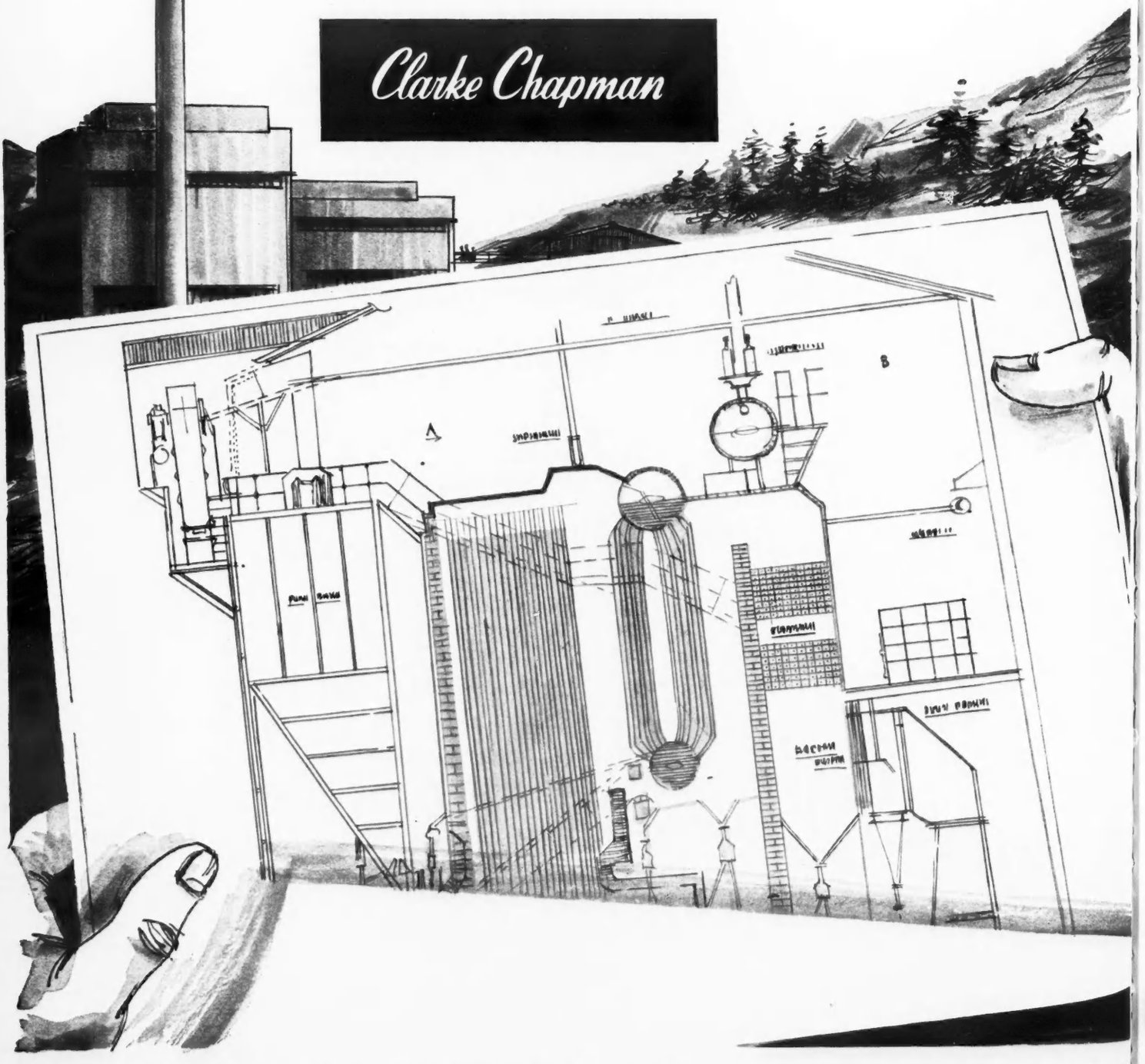

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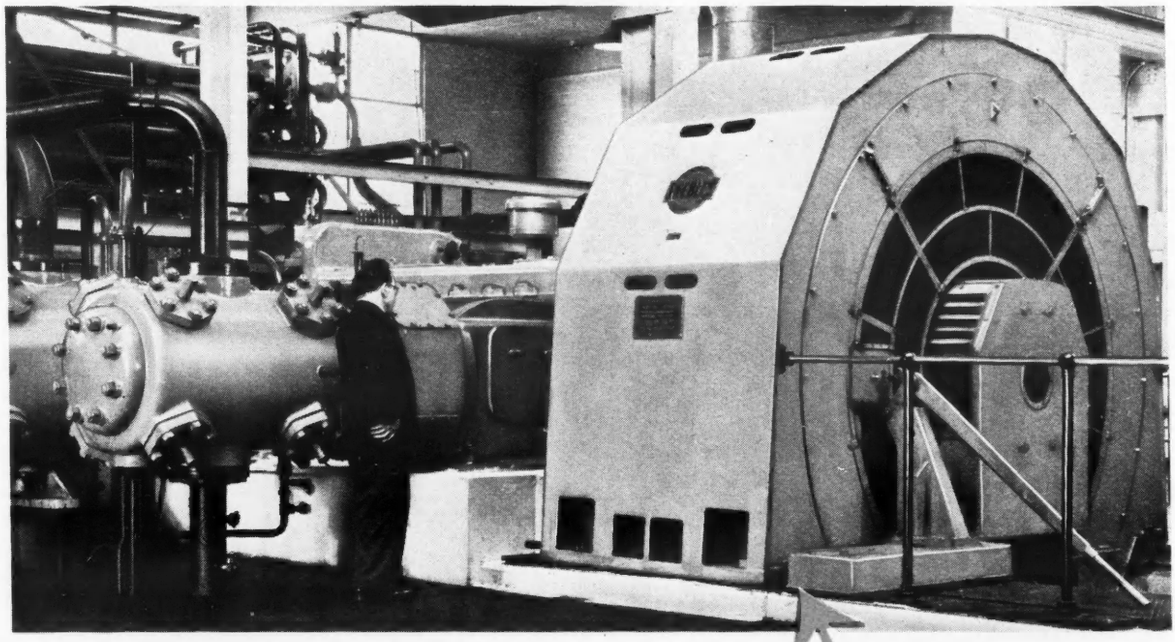

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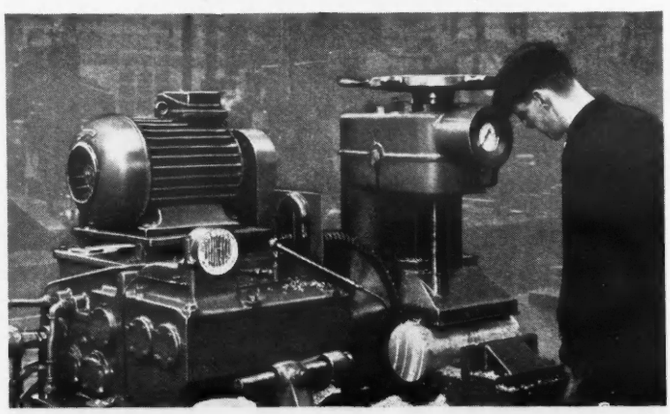

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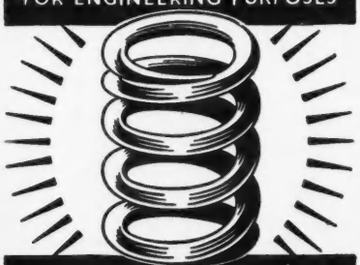

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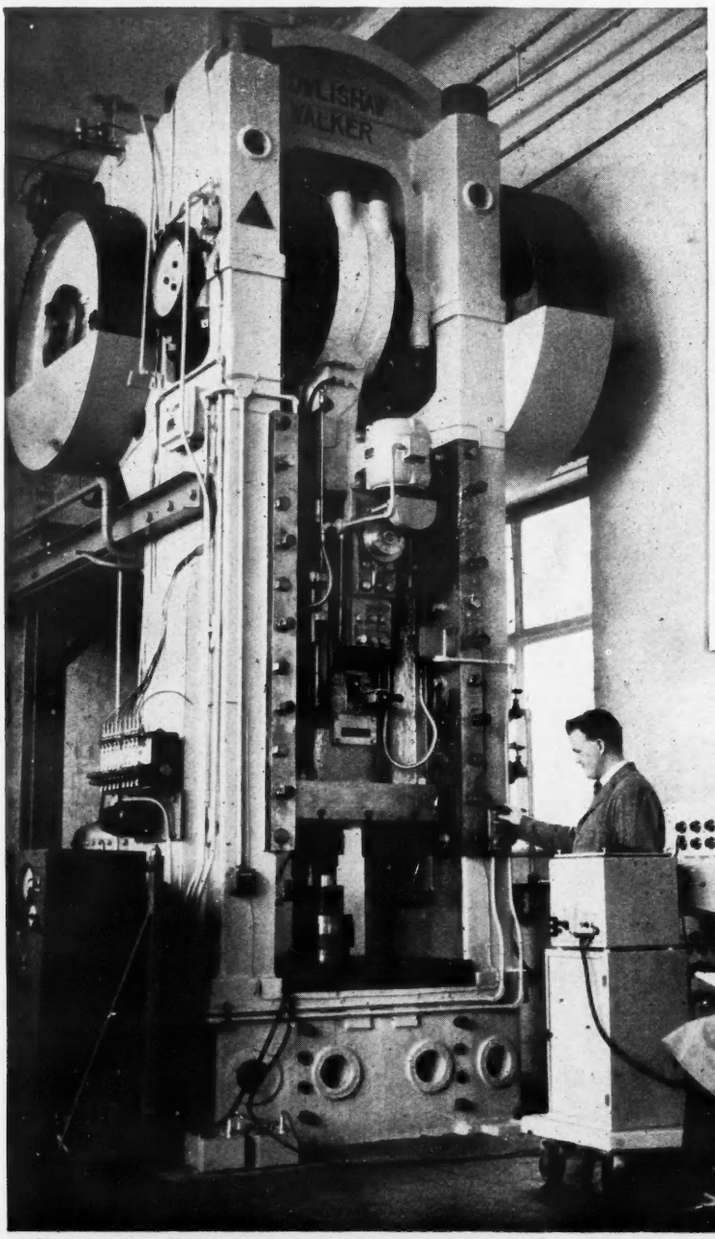

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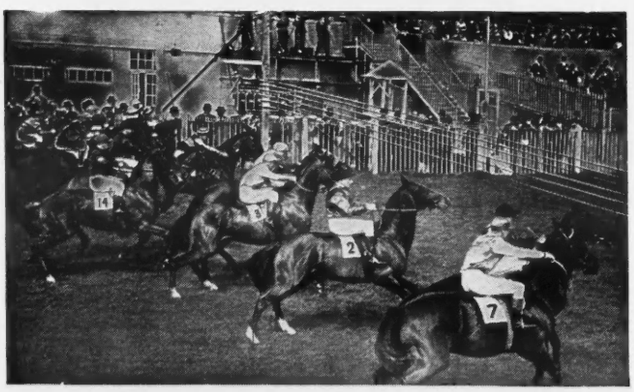

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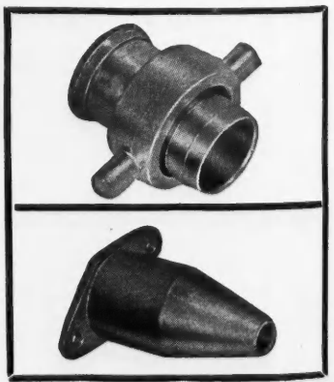

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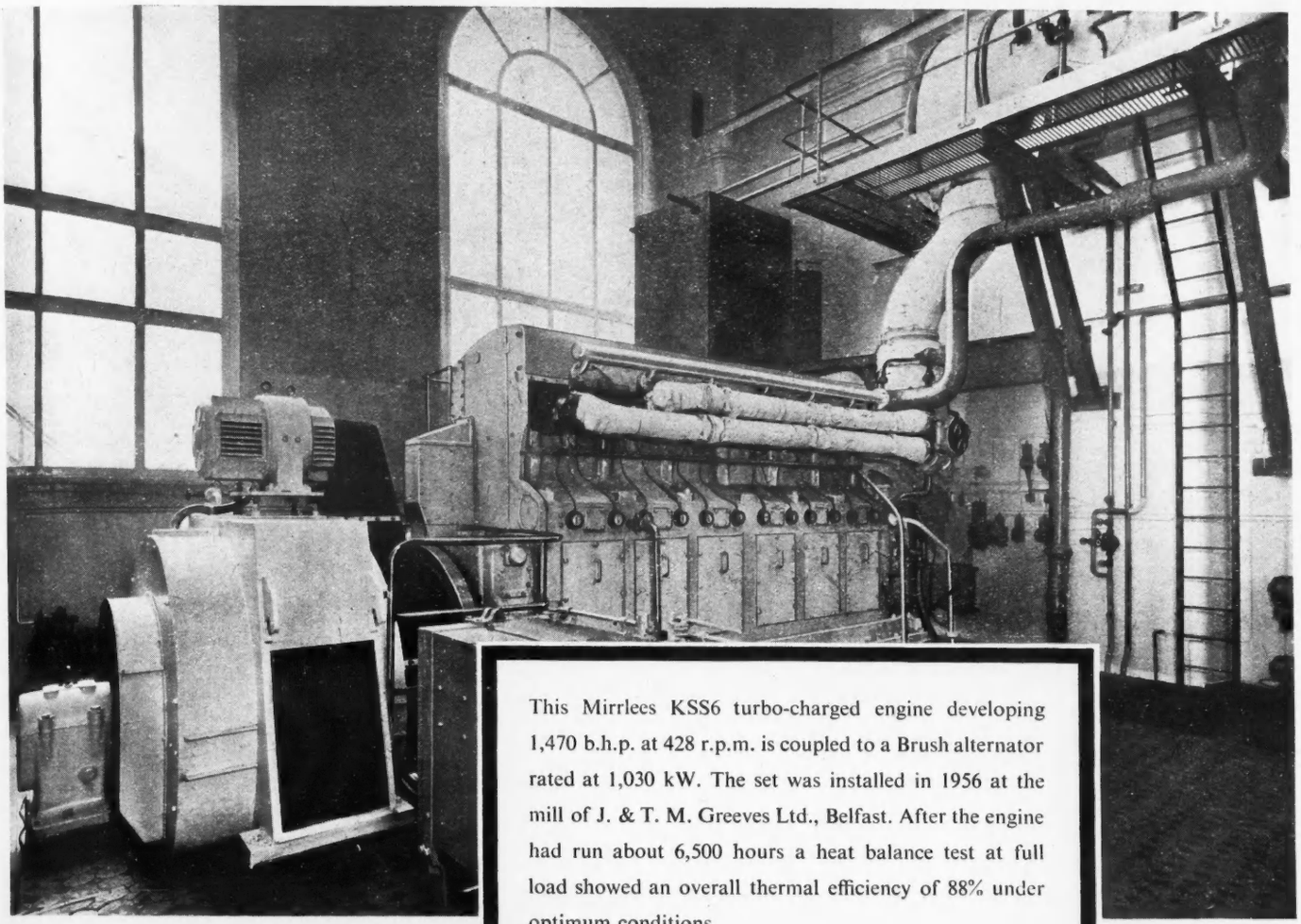

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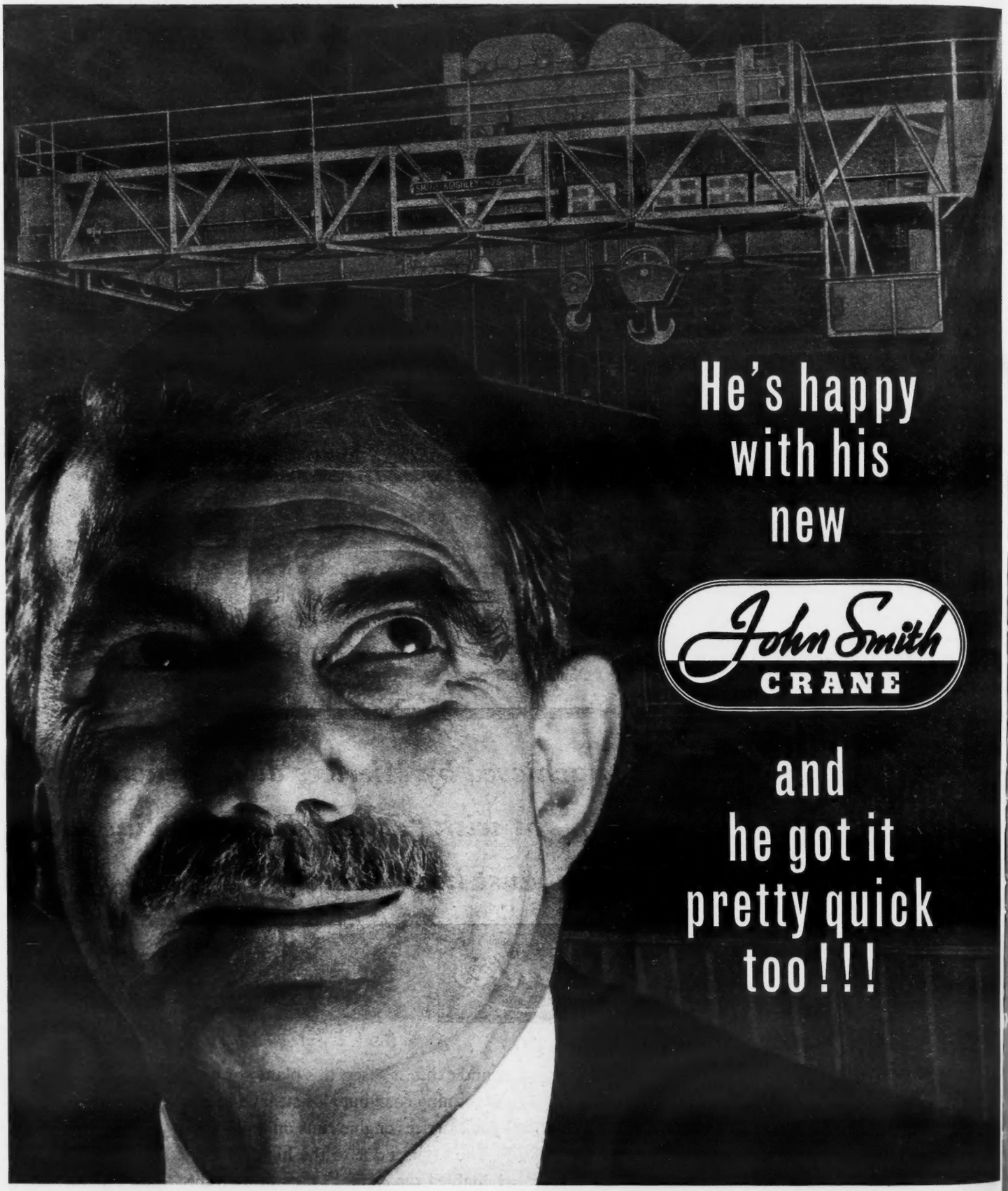

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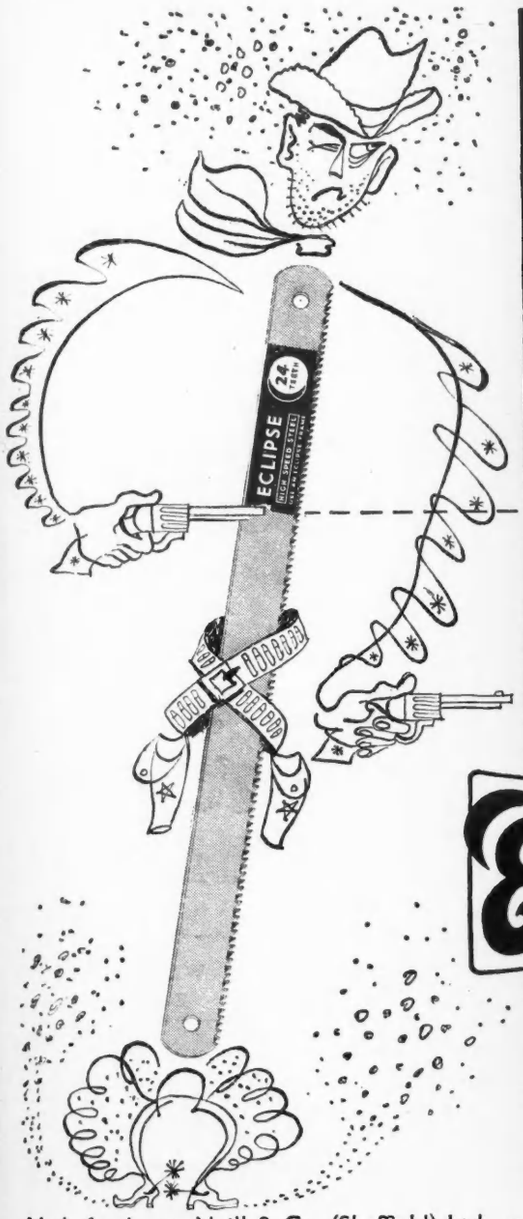

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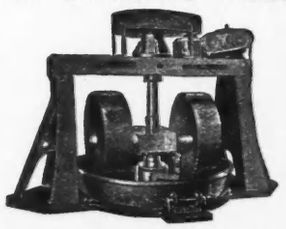

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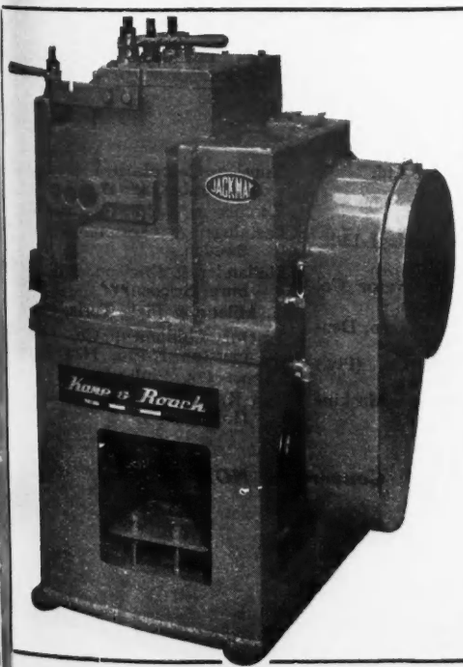

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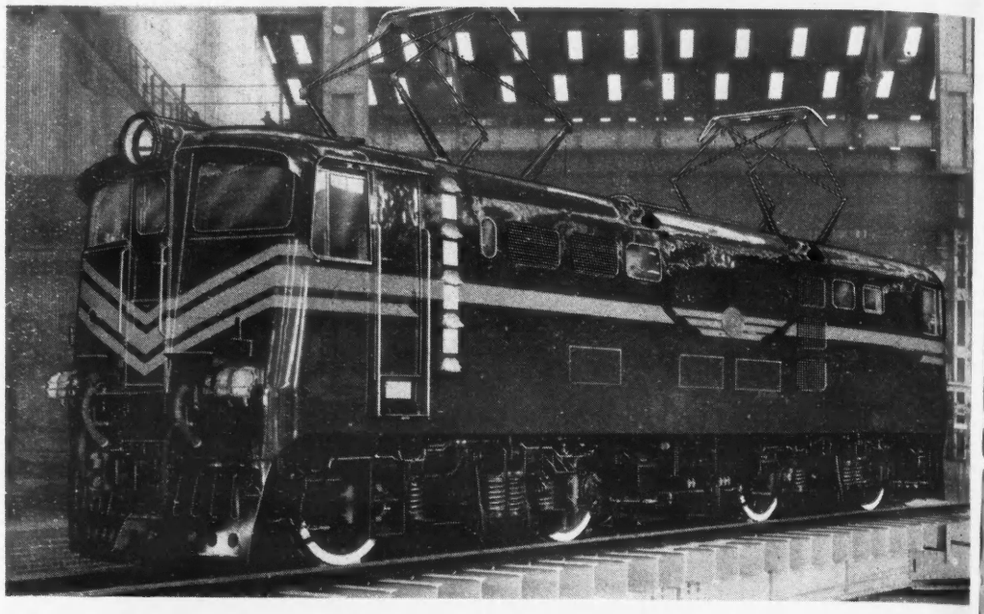

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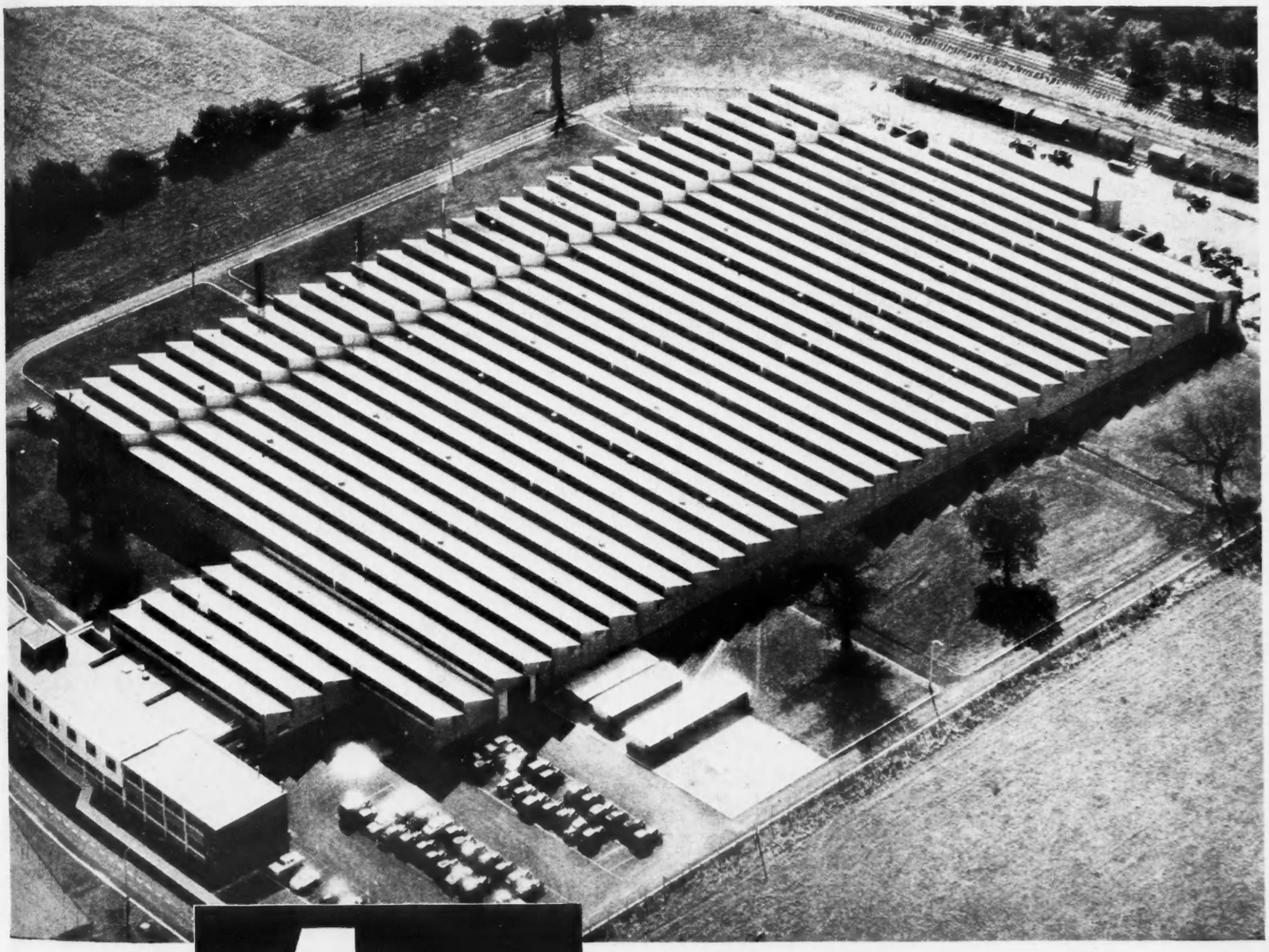

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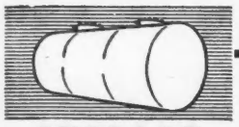

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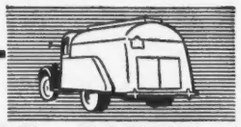

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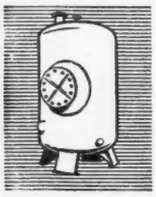

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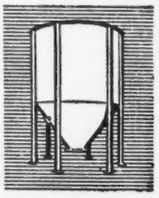

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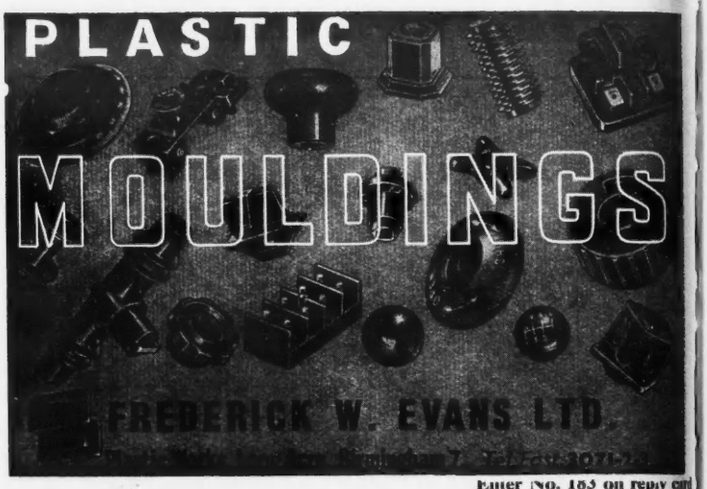

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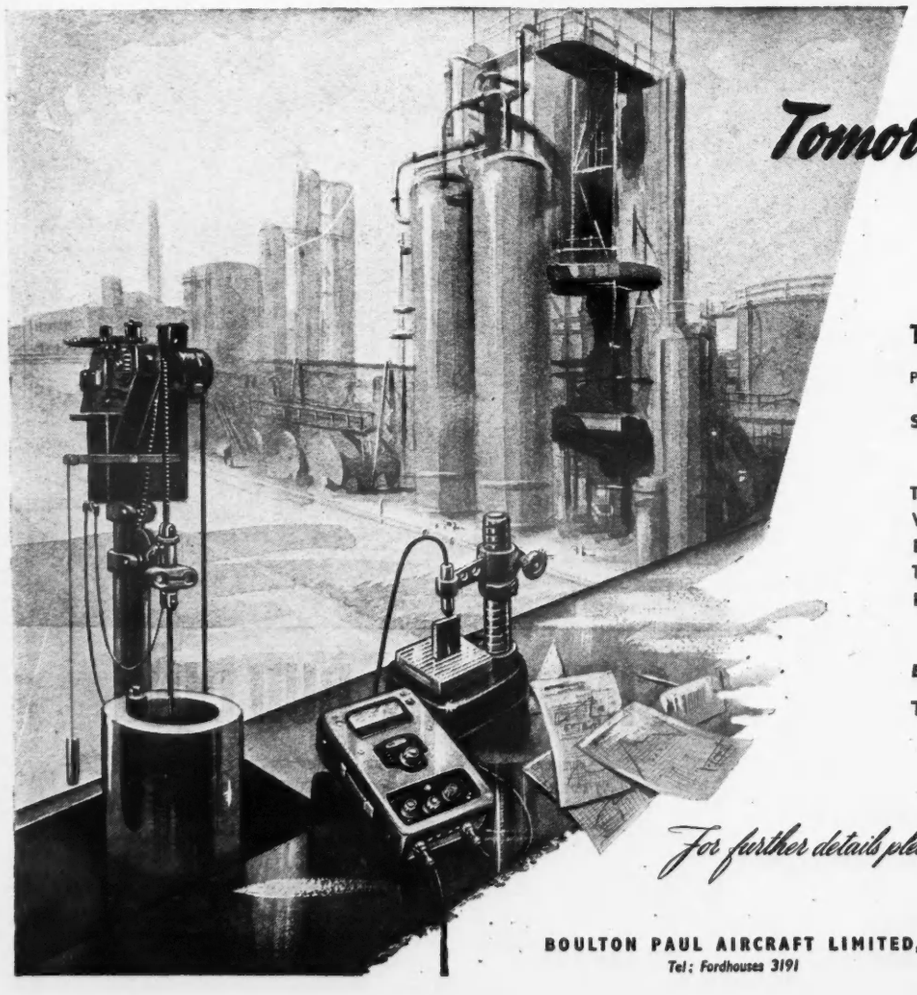

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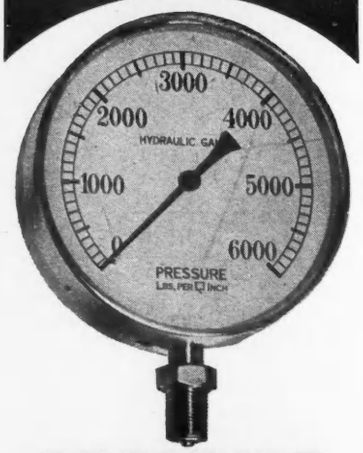

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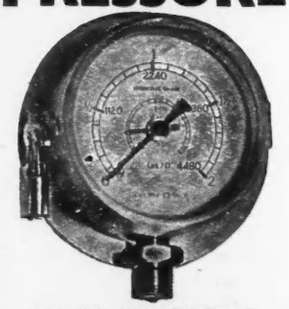

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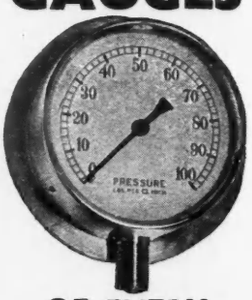

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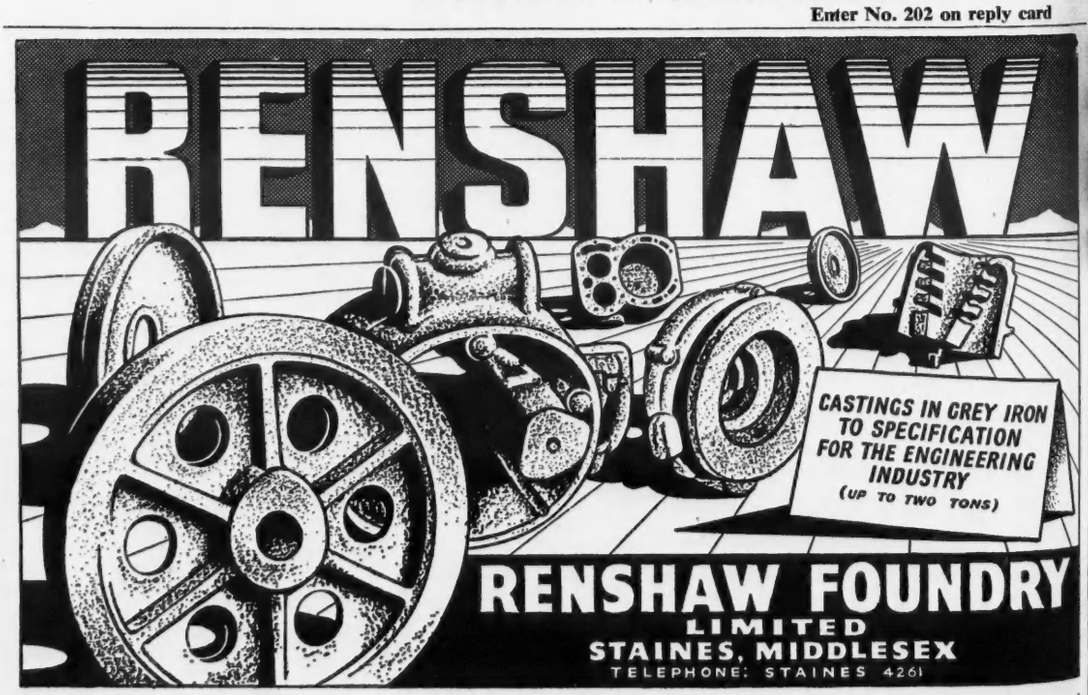

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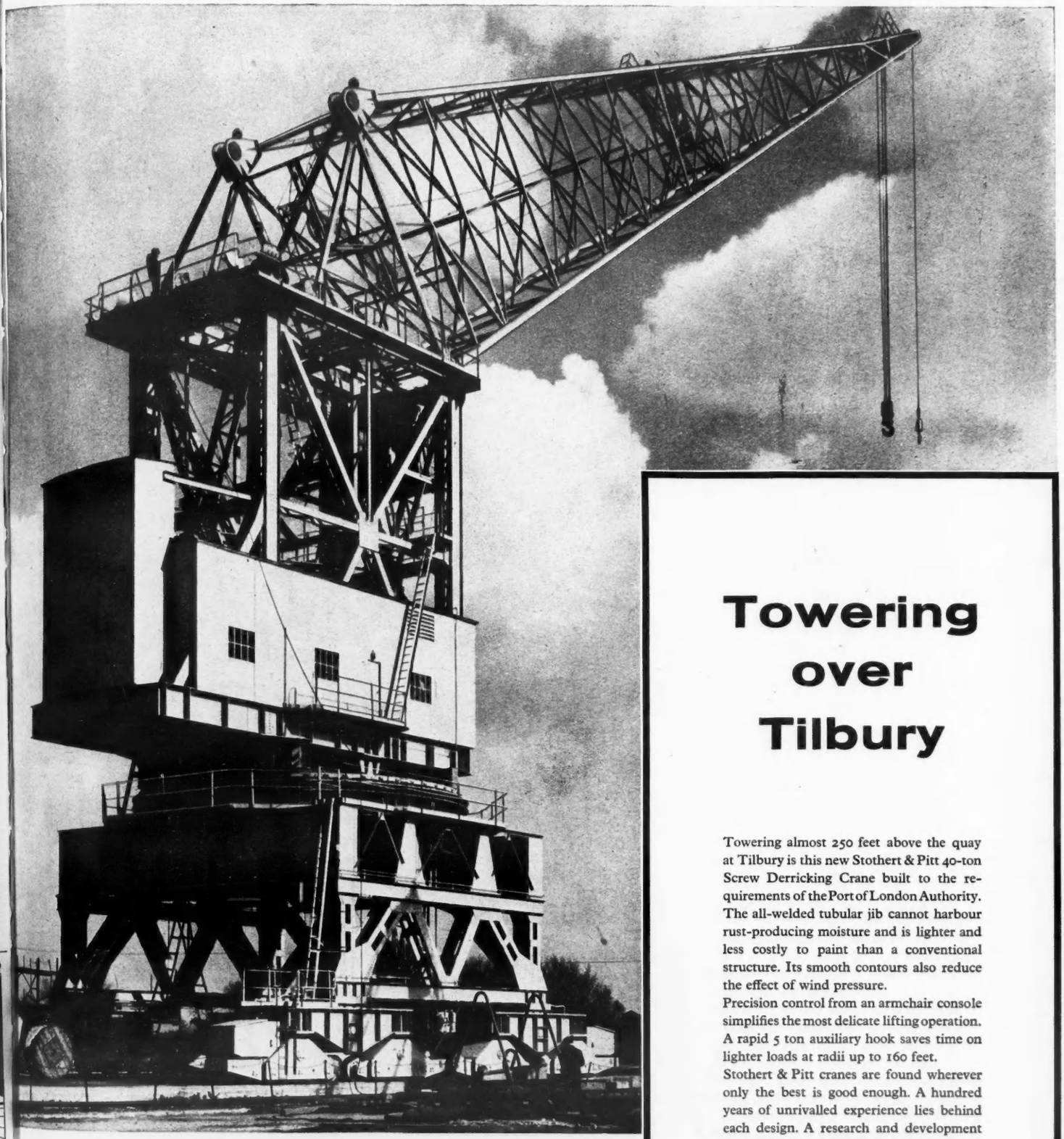

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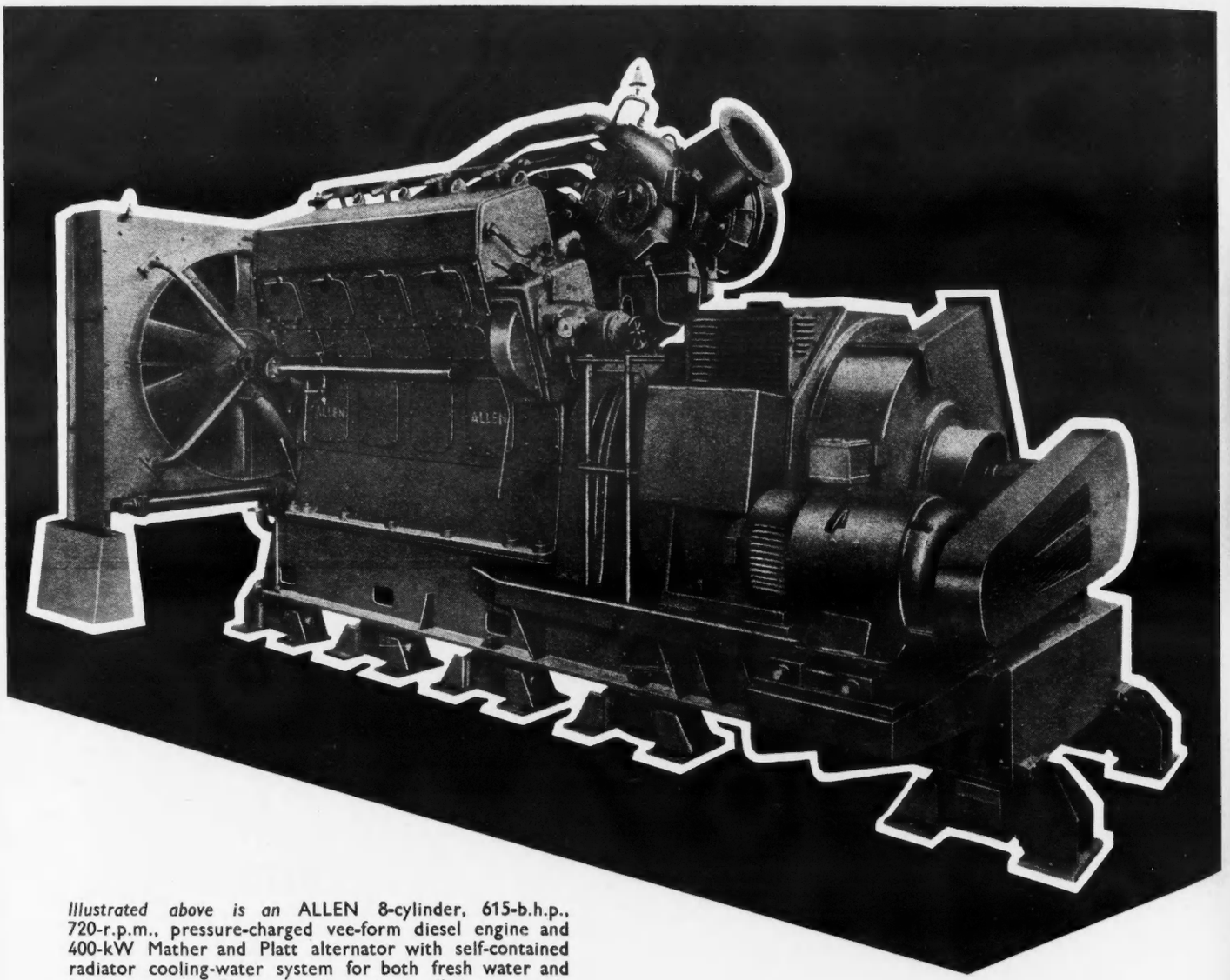

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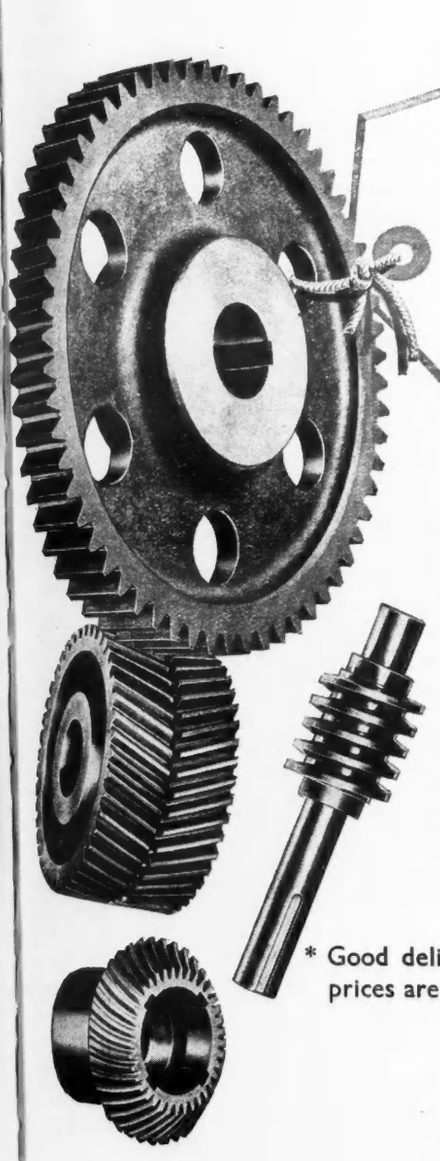

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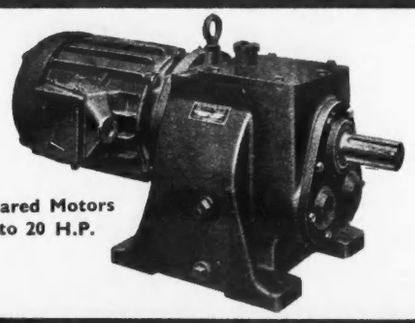

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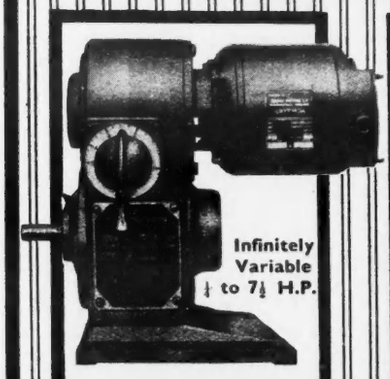

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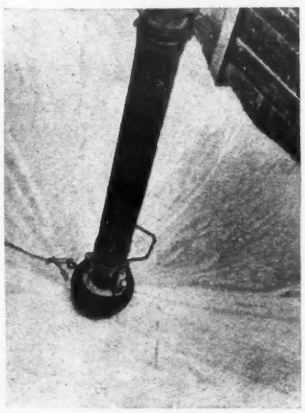

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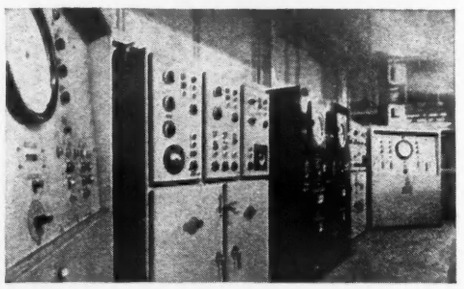

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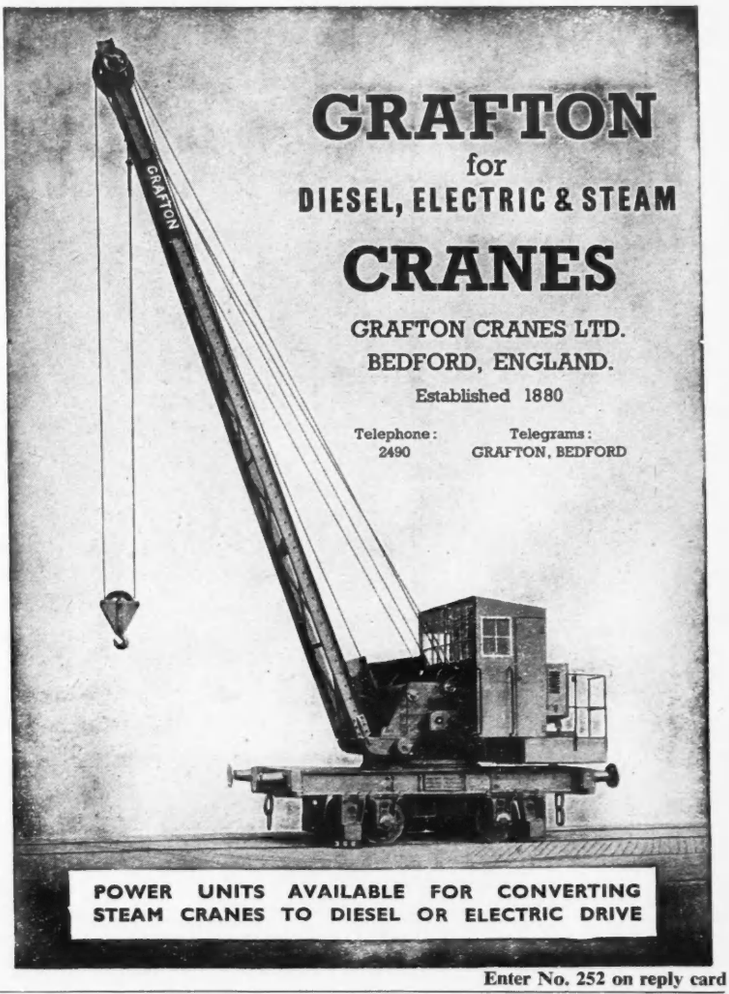

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WHAT IS A FELLMONGER?

Photo by courtesy of Barrow, Hepburn & Gale Ltd.

A worthy quizmaster question?

When supplying a pump for dealing with Sodium Sulphide/Lime Paste we knew a good deal about pumping the paste, but a little puzzled about Fellmongers. But there is the Mono Pump tucked away on a machine for fellmongers who prepare woolled sheepskins. Only one of the many, many duties performed by Mono Pumps on many machines, in many factories, on many processes —commonplace or outlandish.

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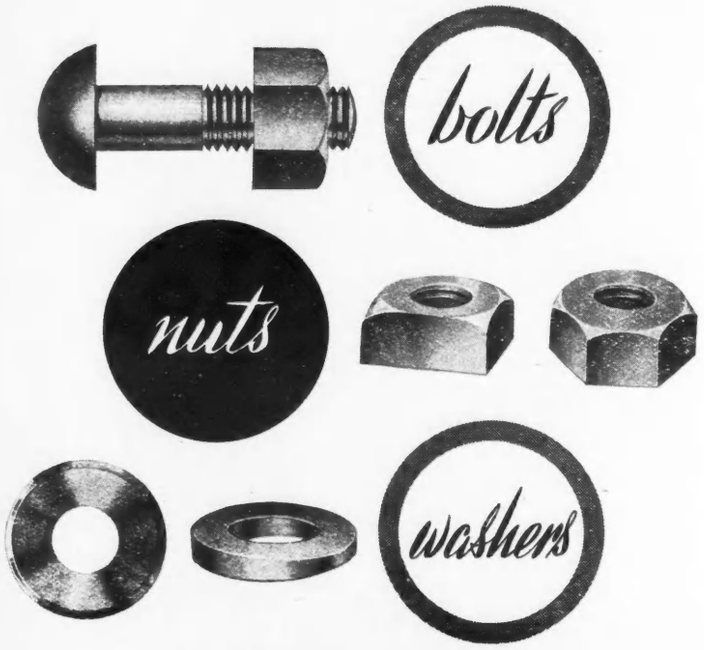

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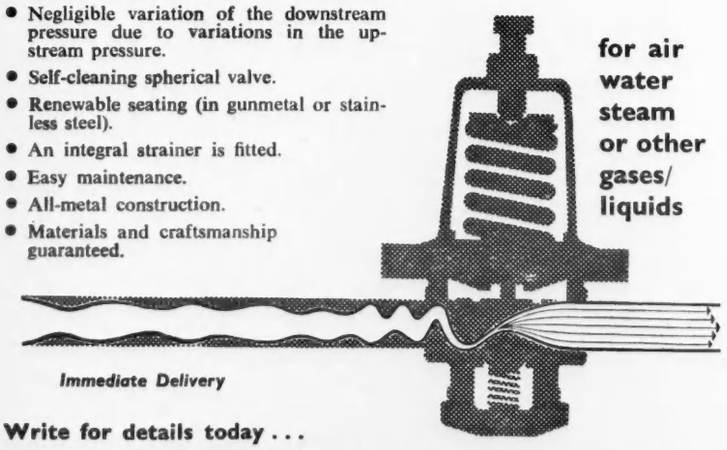

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TELESIG Screw Pumps offer the following advantages:

- Self priming.
- Delivery free from pressure pulsation.
- High working speed — small size.
- Near-silent operation.
- Simple construction.
- Minimum maintenance and easy replacement of working parts.
- Long life.

TELESIG Screw Pumps are made in three basic ranges: for low pressures up to 300 psi, for medium pressure up to 1000 psi and for high pressures up to 2,500 psi. 42 sizes are available covering a wide range of capacities.

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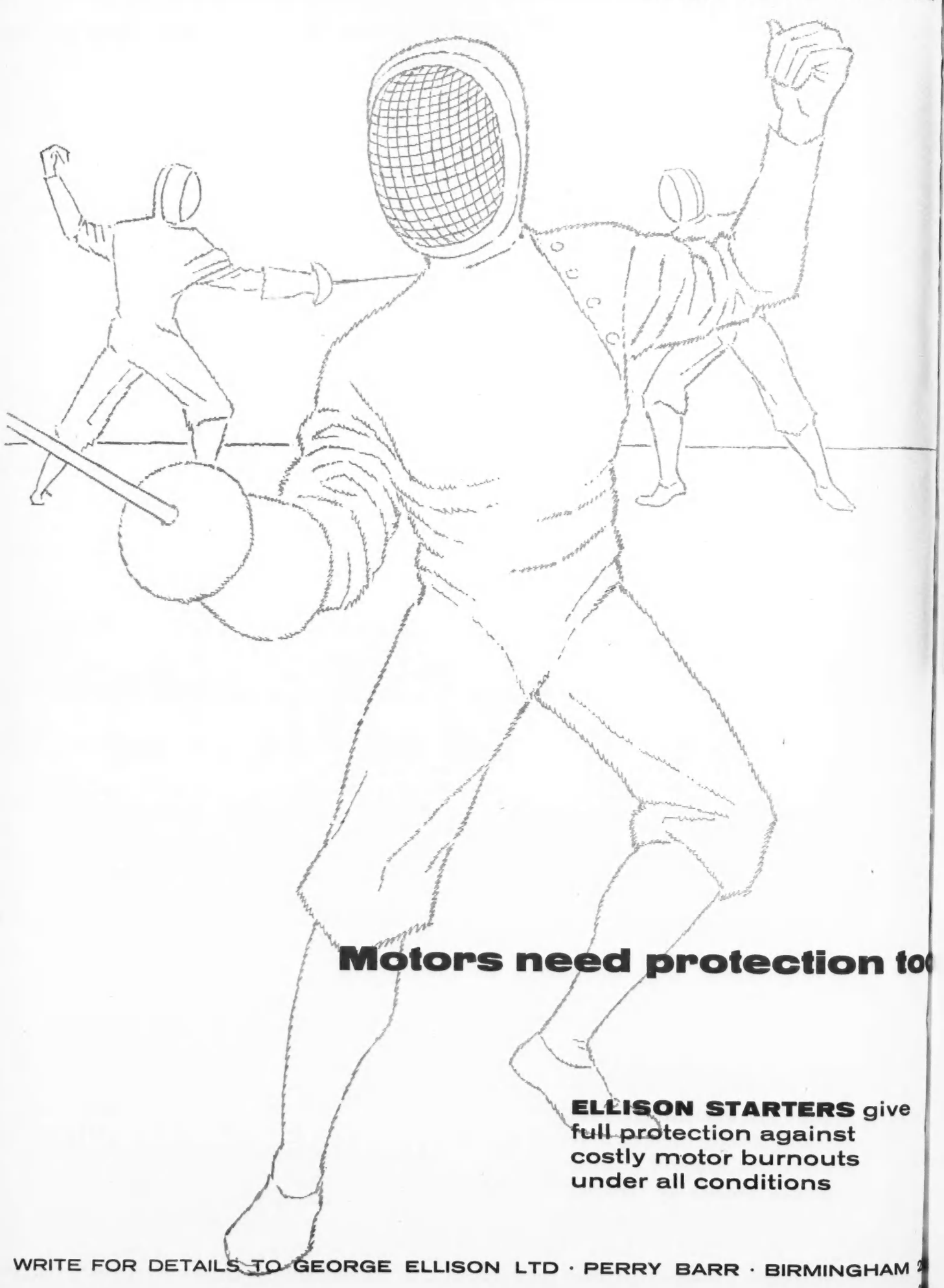

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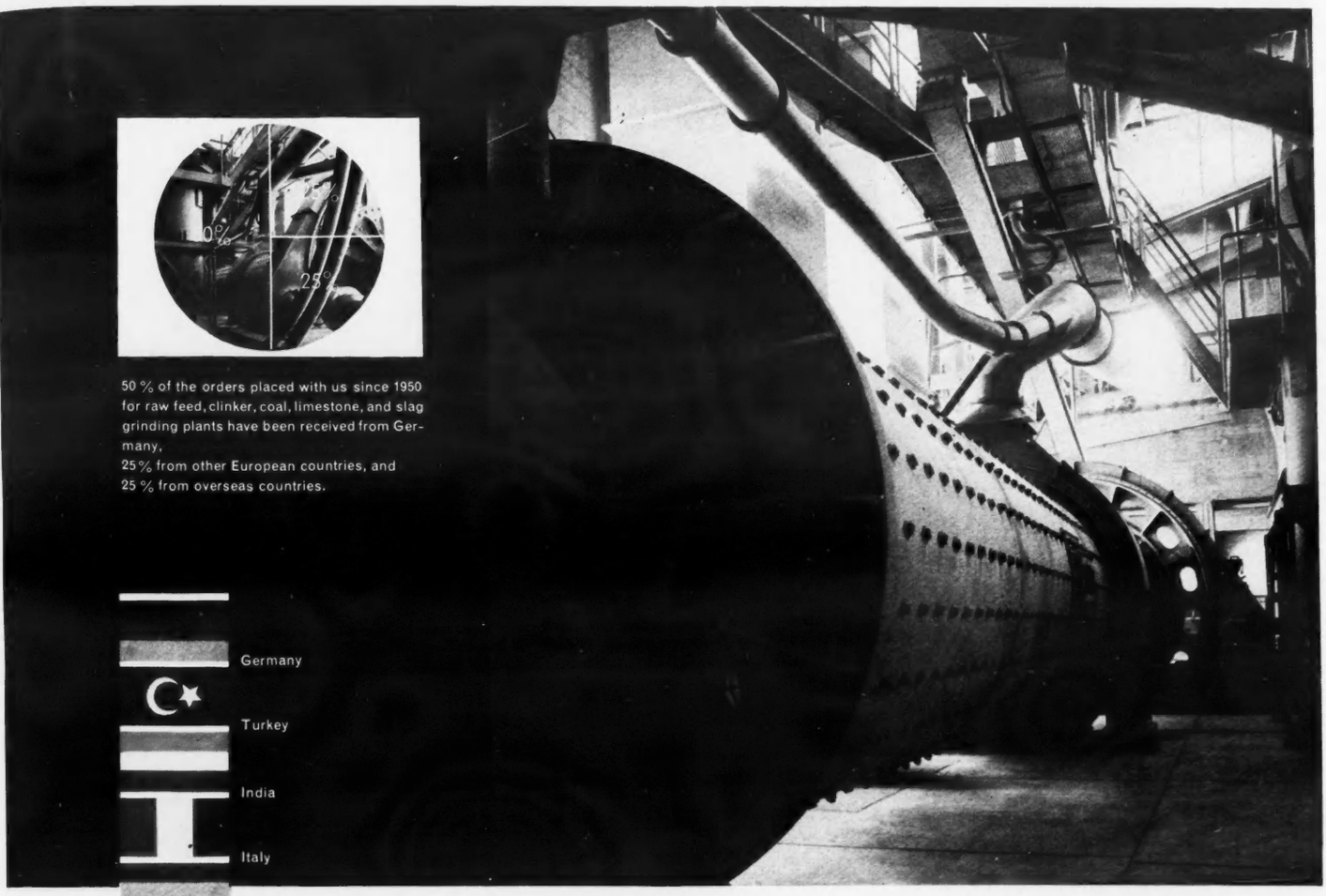
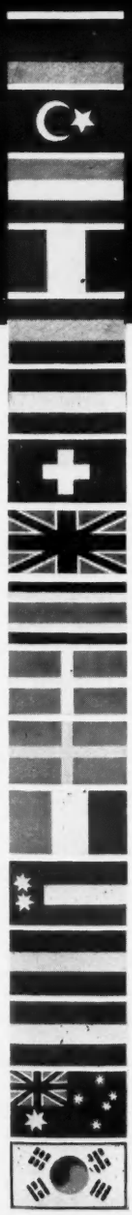
25 % from overseas countries.





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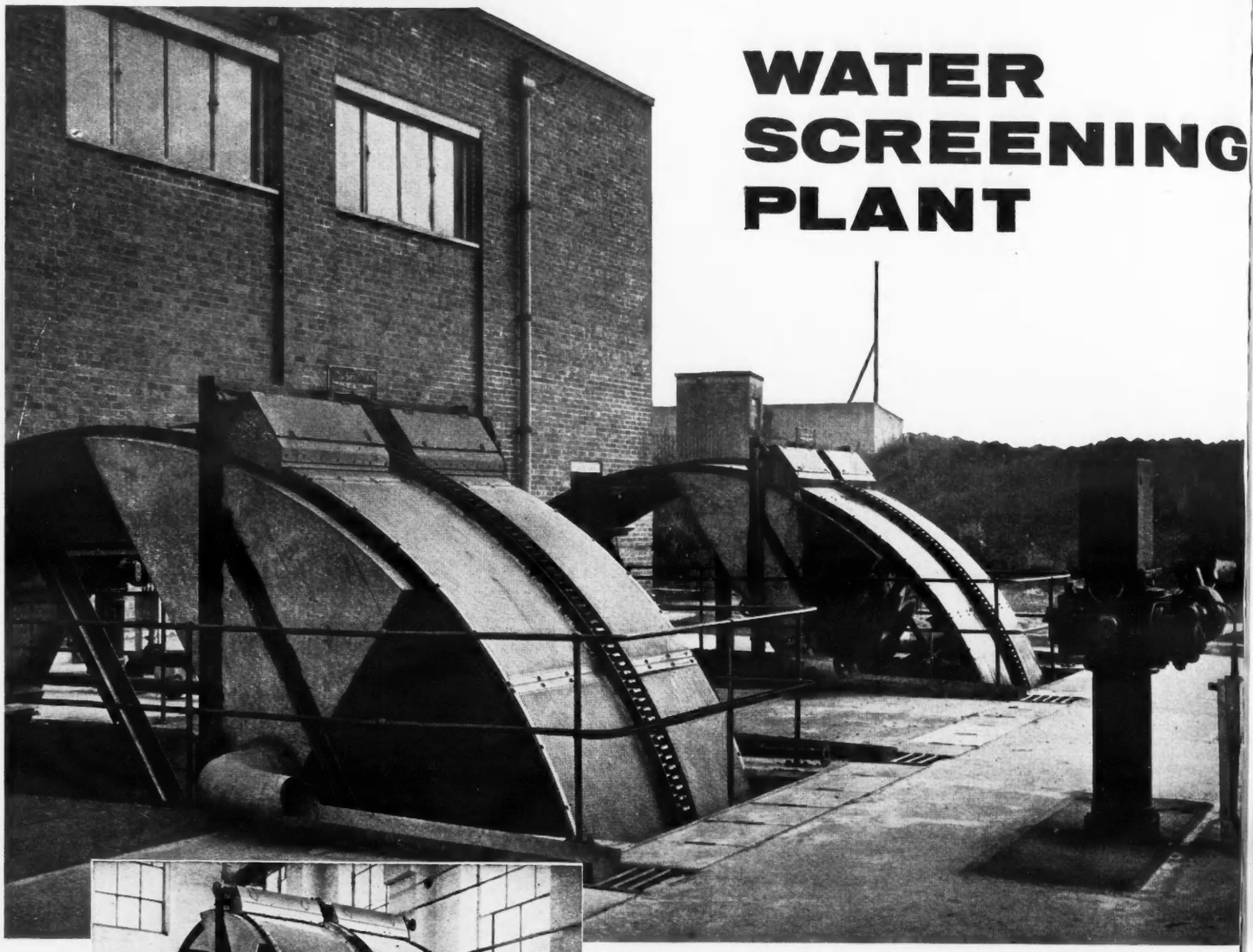

Built to the most advanced specifications for efficient service, with low operating costs, high resistance to wear and corrosion, and ability to withstand full overload in emergency, Blakeborough self-cleaning screens have proved their value many times over on power station circulating water and other applications.

The examples illustrated are of Revolving Drum pattern. Amongst recent orders for this type are the four 38ft. diameter units supplied for Kincardine Power Station of the South of Scotland Electricity Board ; and the six 30ft. diameter units at present in hand for Uskmouth Power Station, of the Central Electricity Generating Board.

The headstock visible on the right of the installation view belongs to the motor-operated screen chamber penstock—another notable Blakeborough speciality.

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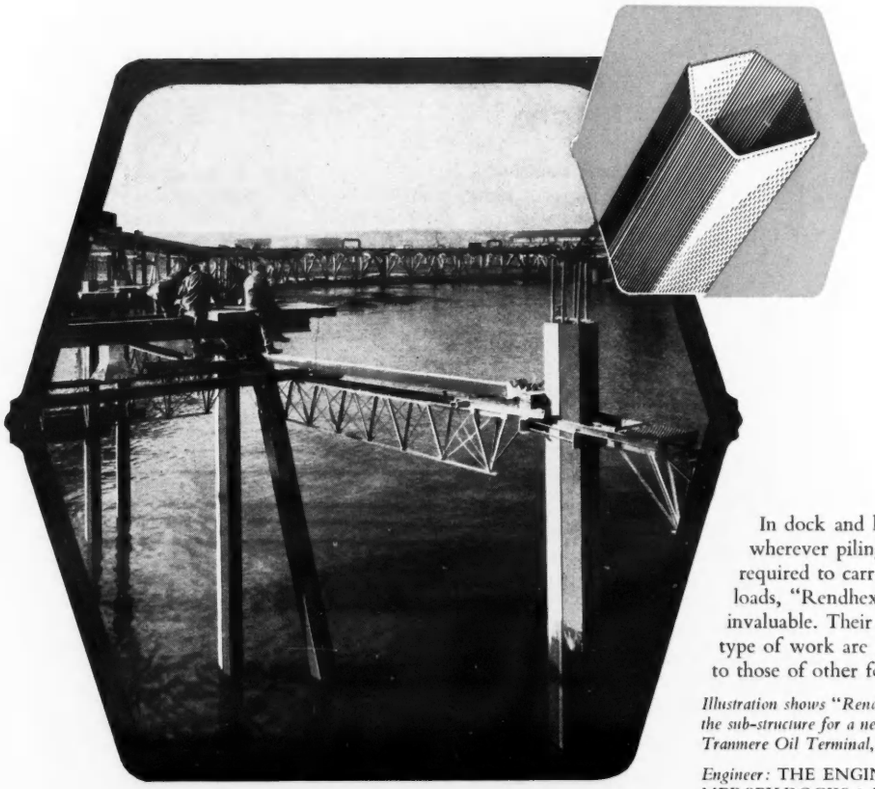

In dock and harbour installations, wherever piling construction is required to carry heavy vertical loads, "Rendhex" Columns are invaluable. Their properties for this type of work are generally superior to those of other forms of piling.

Illustration shows "Rendhex" Columns forming the sub-structure for a new oil tanker jetty at Tranmere Oil Terminal, Birkenhead.

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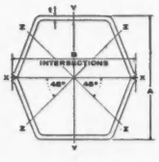

TABLE OF PROPERTIES

"Rendhex" Column No.	Size (Ins.)			Weight of Rolled Section lbs. per Lin. ft.	Weight of complete Col. (incl. Weld) lbs. per Lin. ft.	Area of complete Col. (excl. weld) Sq. ins.	Moment of Inertia (Ins.⁴)			Radii of Gyration (Ins.)			Section Moduli (Ins.³)		
	A	B	t				About XX	About YY	About ZZ	About XX	About YY	About ZZ	About XX	About YY	About ZZ
No. 3	13	12⅞	½	36·15	72.50	21·26	469·3	381·3	425·3	4·69	4·23	4·47	72.20	58·70	57·30
No. 4	16	16⅛	⅝	58·30	117·75	34·30	1214	1038	1126	5·95	5·50	5·73	151·75	125·82	116·15
No. 6	20	20	0·7	80·70	162·80	47·47	2657·7	2203·5	2430·6	7·49	6·81	7·16	265·80	218·60	207·20

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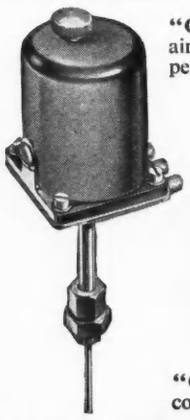
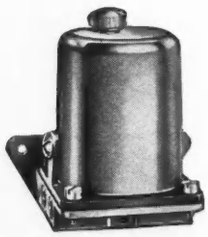
TRANSMISSION

CONTROL



"On plant" mercury-in-steel air-operated proportional temperature controller. *Publication No. R39*



"On line" air-operated receiving controller. *Publication No. R31*

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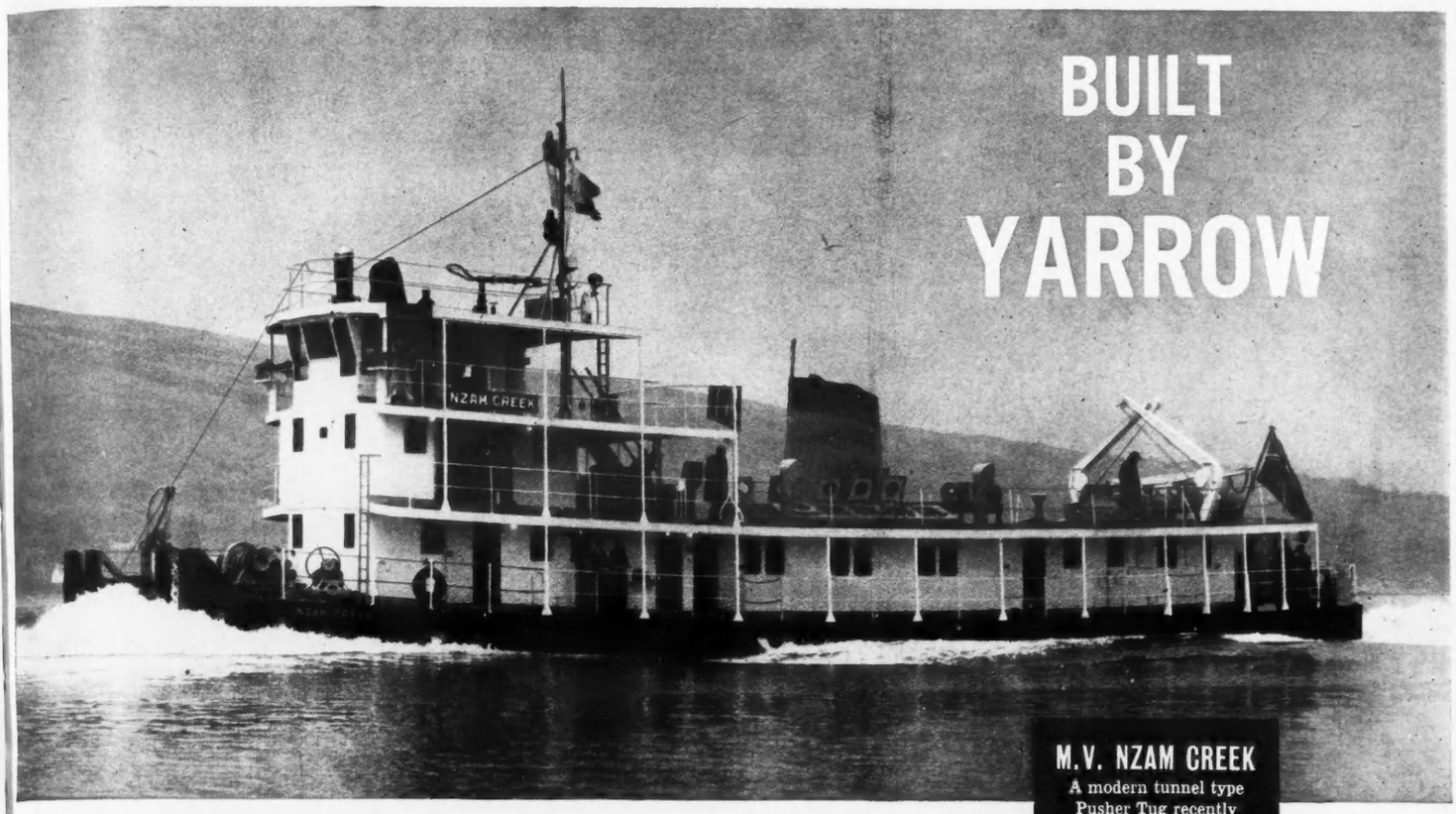

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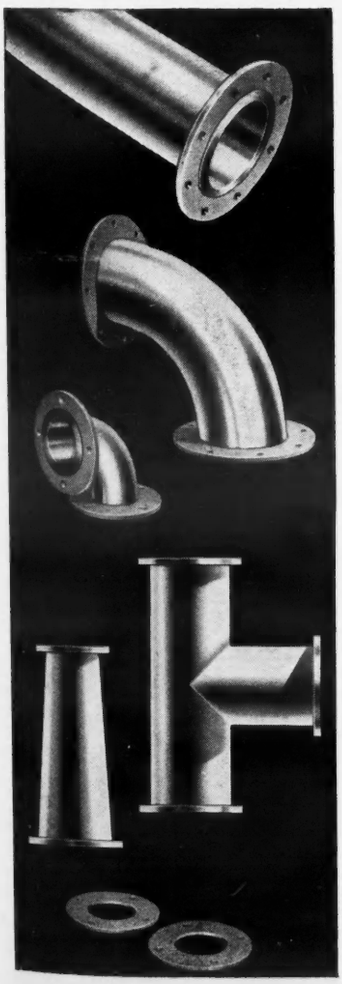

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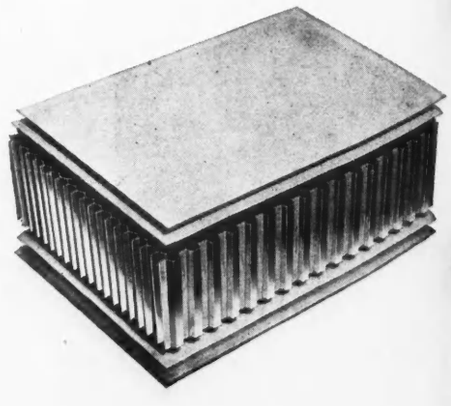

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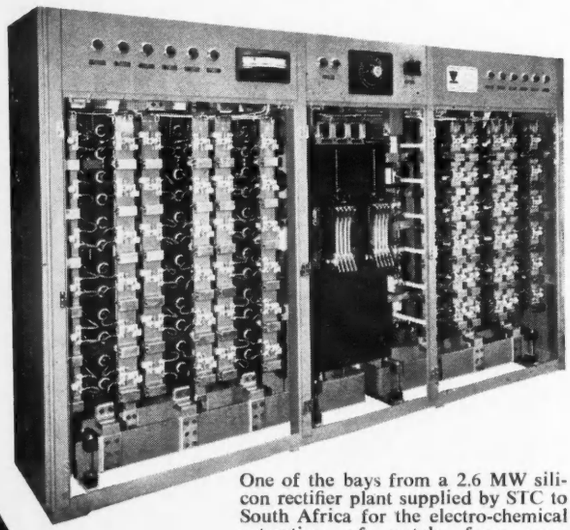

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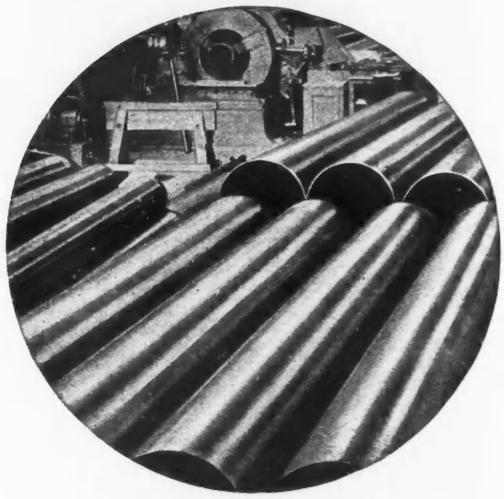

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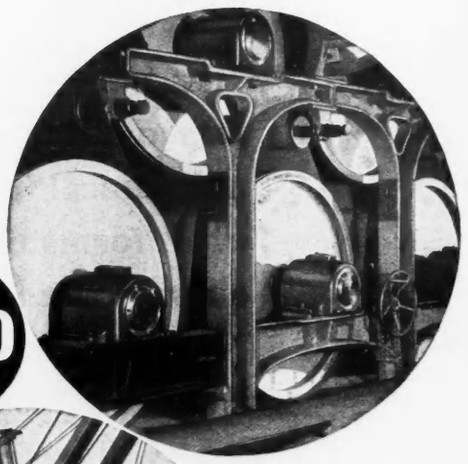

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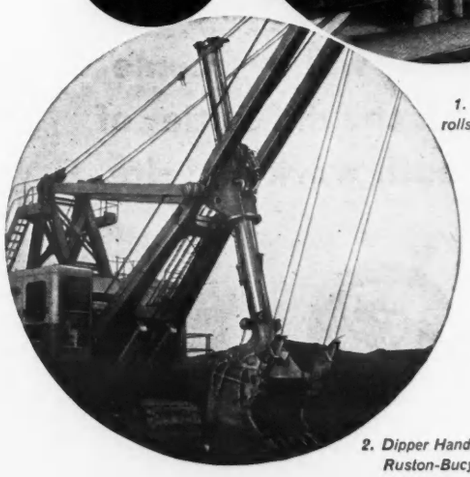

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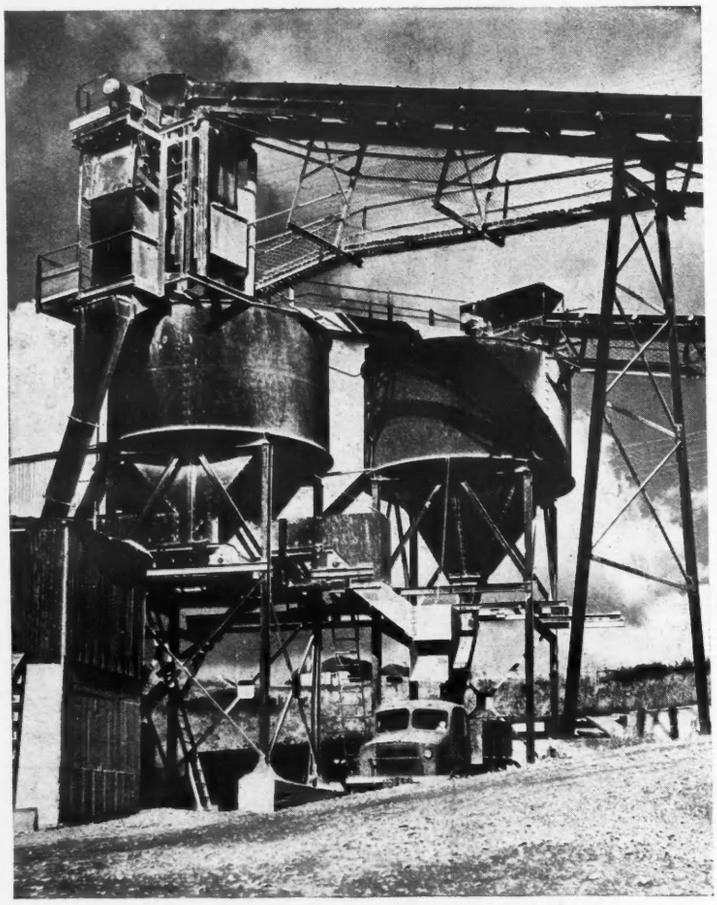

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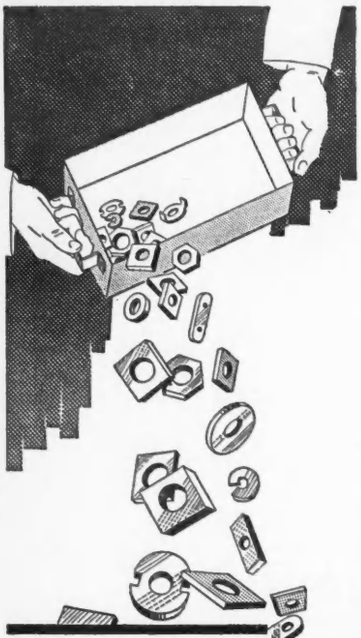

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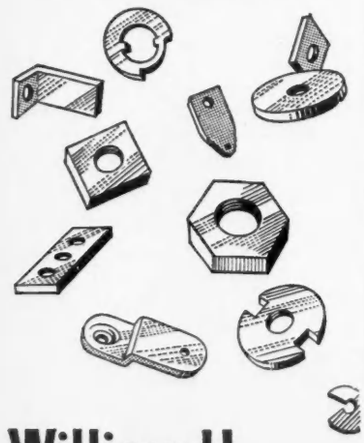

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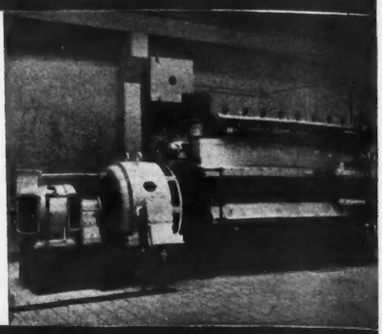

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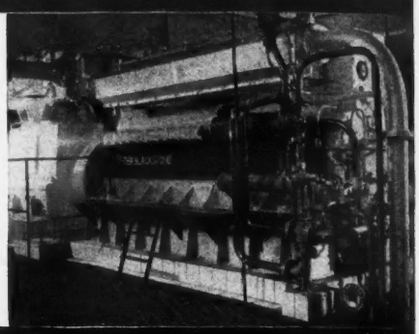

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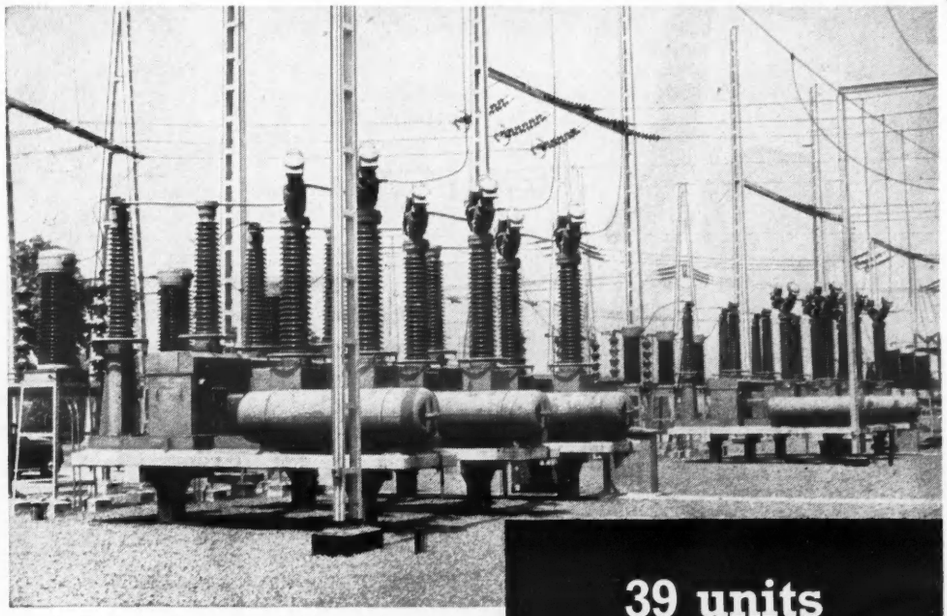

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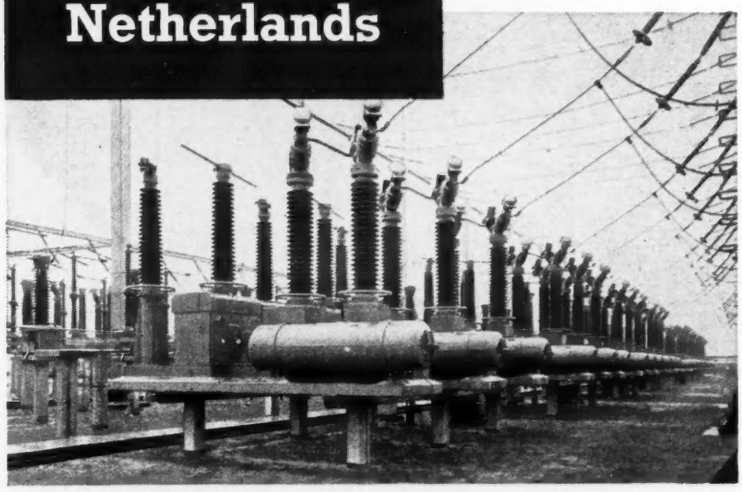

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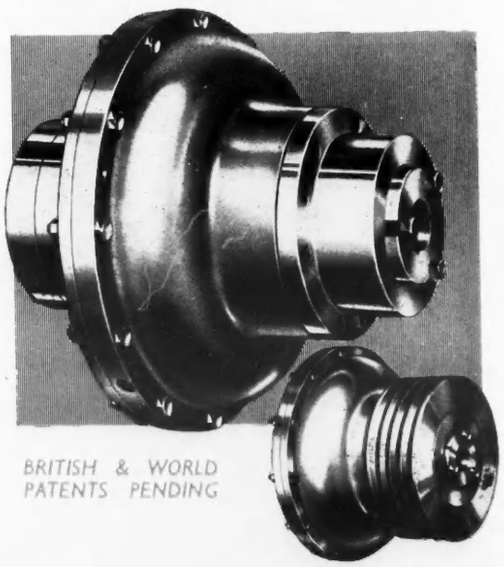

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GREATER DRILLING ACCURACY—thanks to the fixed ladder base and pre-positioning of drills for pattern drilling.

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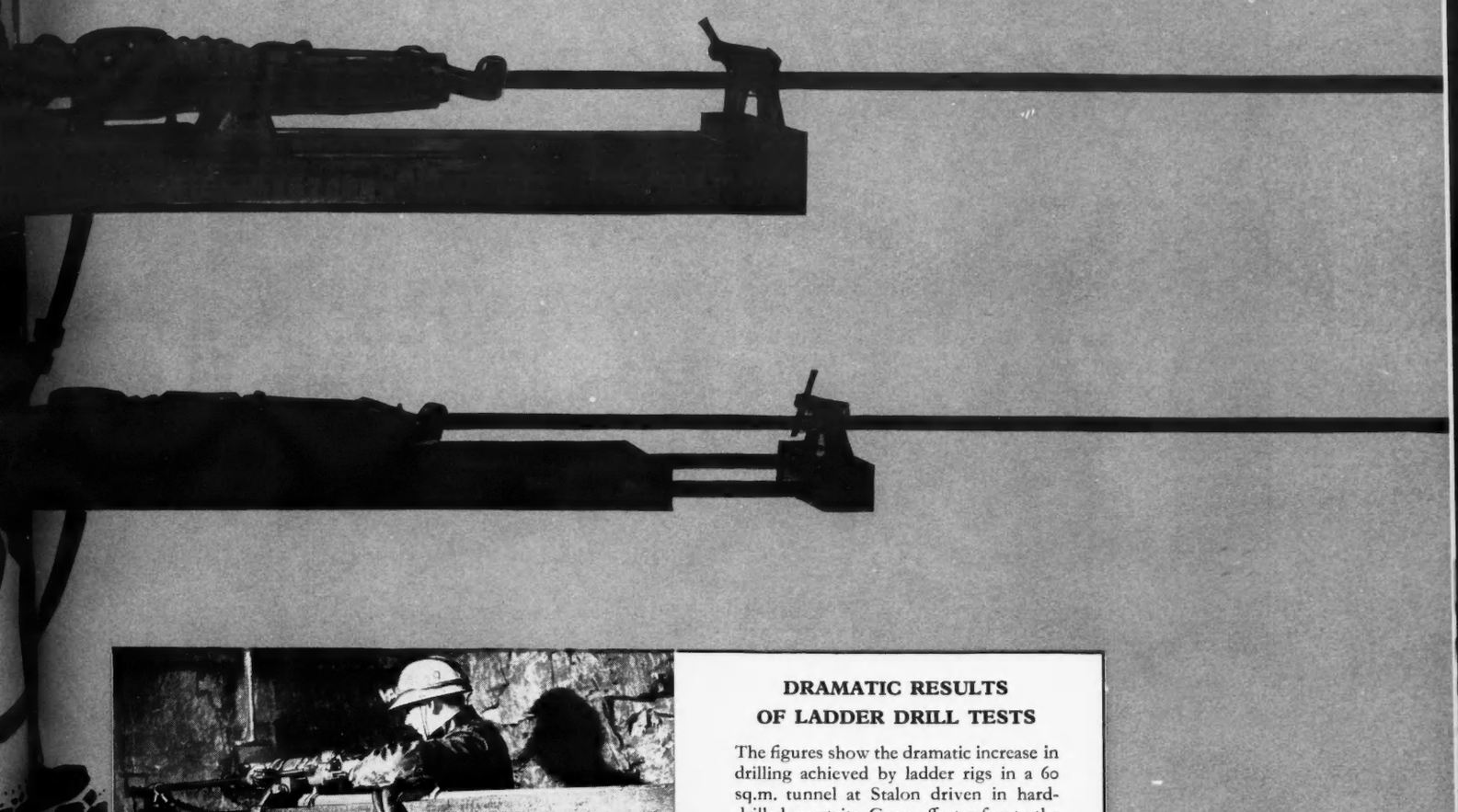

DRAMATIC RESULTS OF LADDER DRILL TESTS

The figures show the dramatic increase in drilling achieved by ladder rigs in a 60 sq.m. tunnel at Stalon driven in hard-drilled quartzite. Gross effect refers to the mean value for the whole drilling period, including collaring, changing steels and the usual routine delays. *Note that the gross effect is exactly doubled.*

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39.0 metres/man-hour Ladder drilling with two drills.

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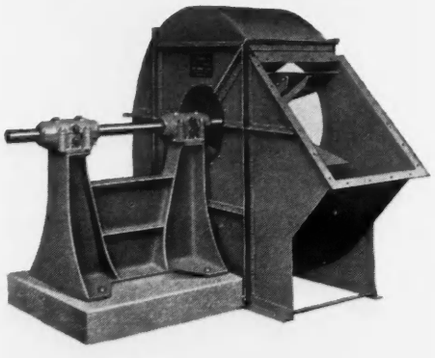

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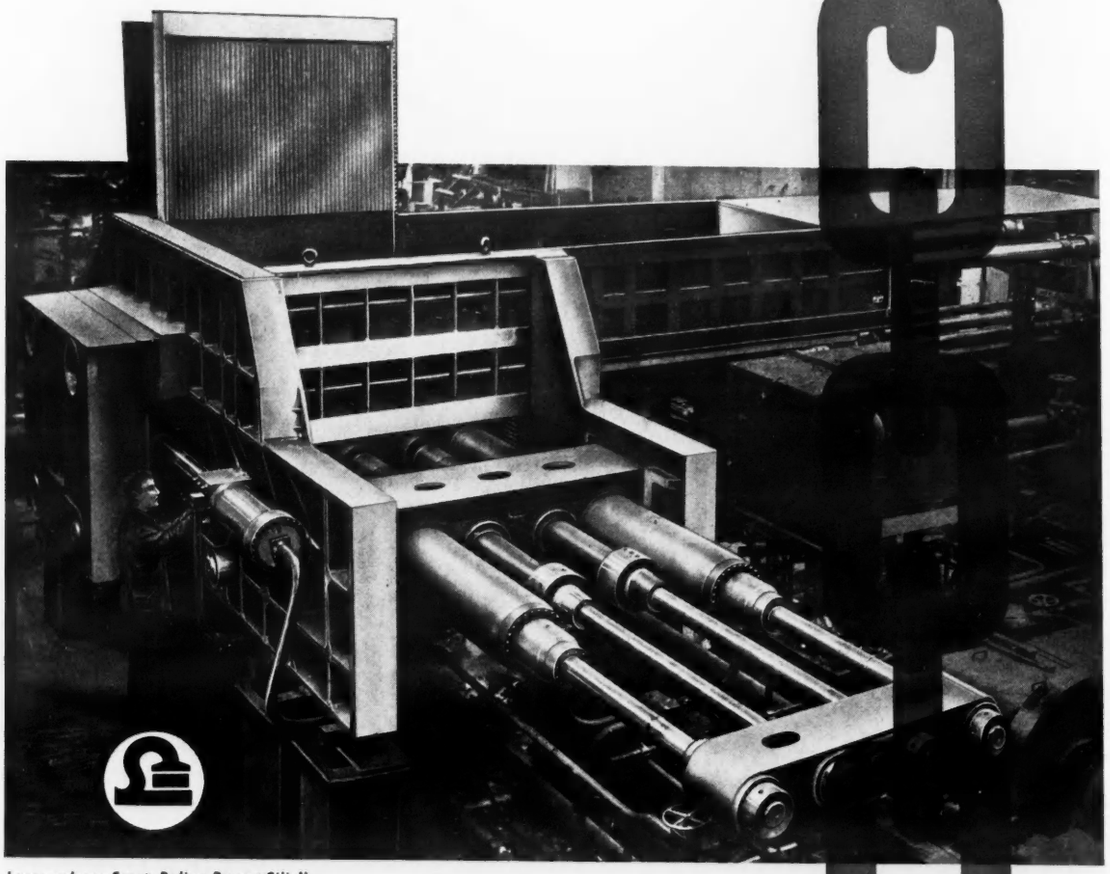

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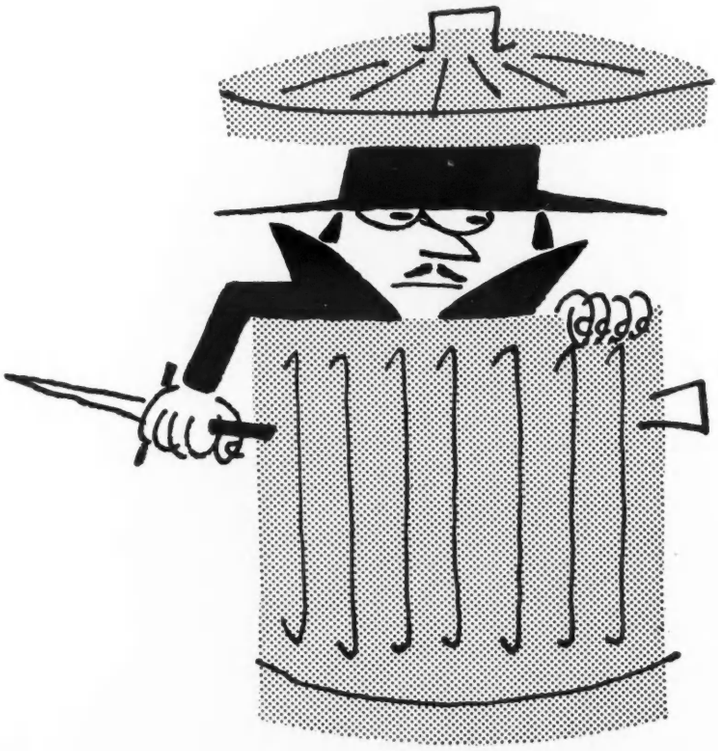

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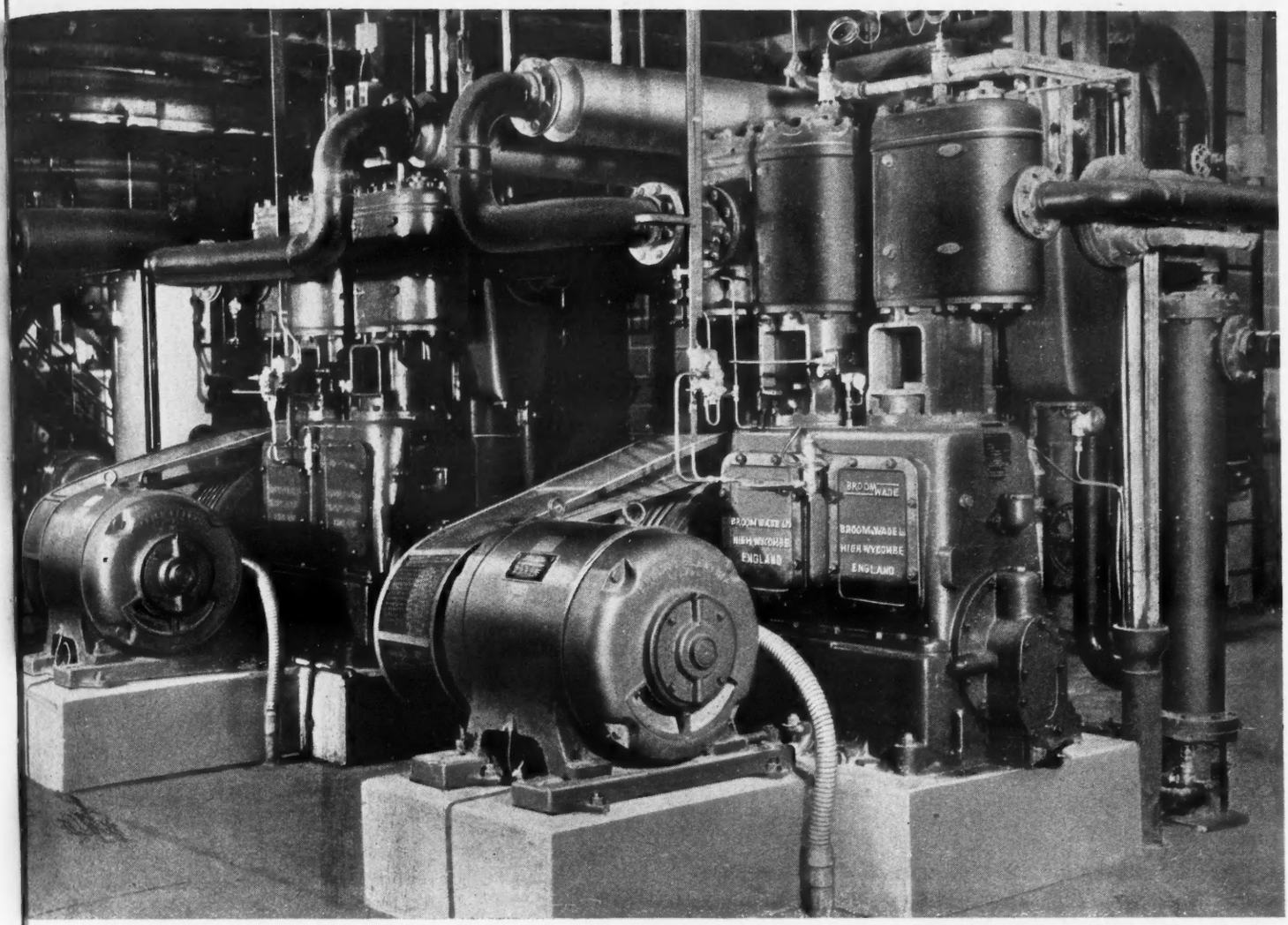

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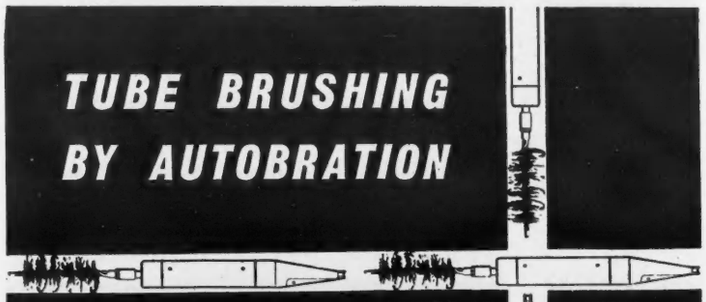

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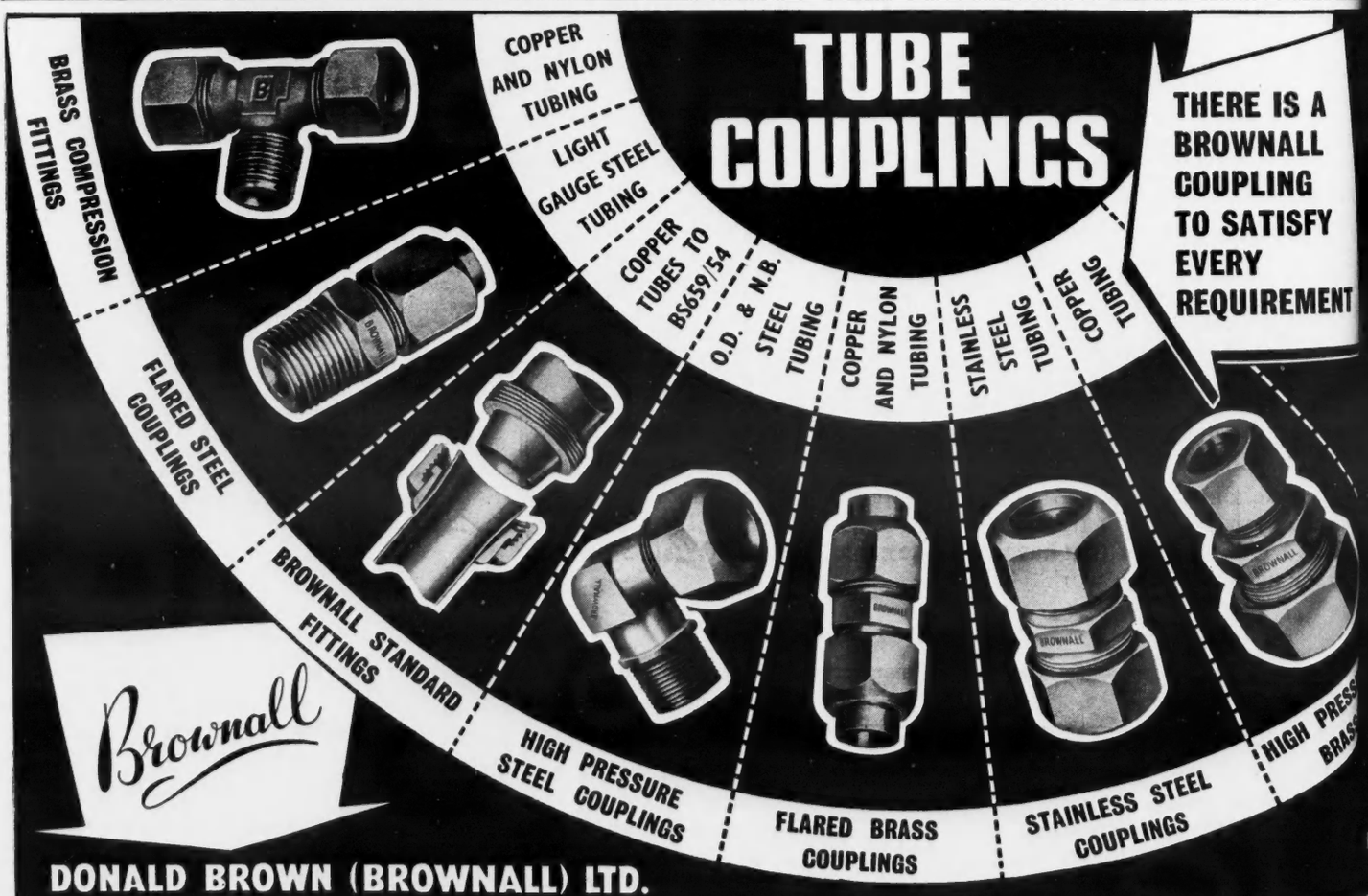

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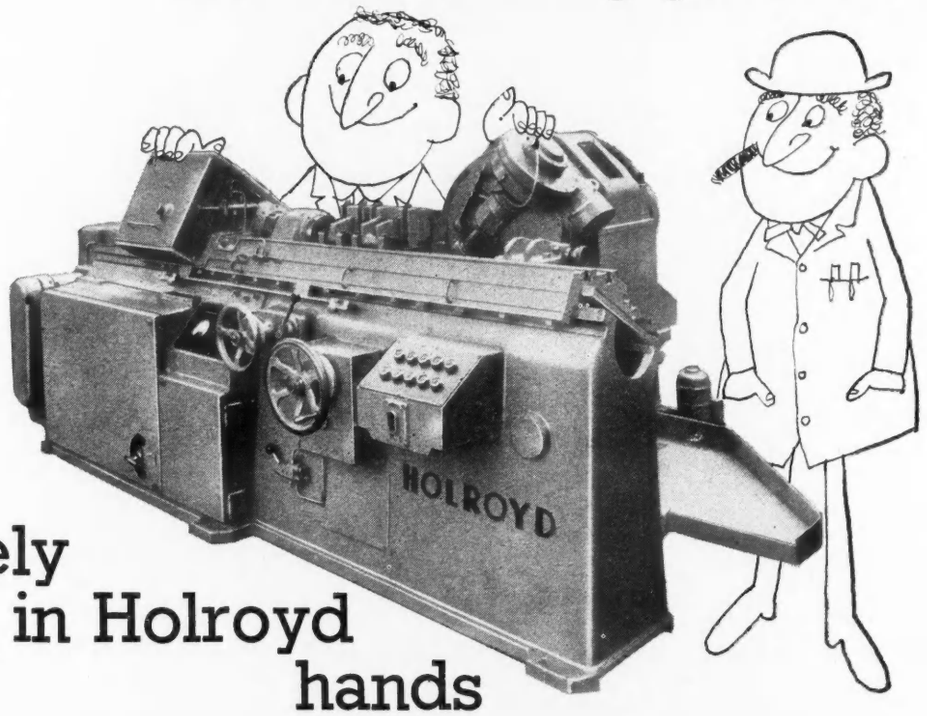

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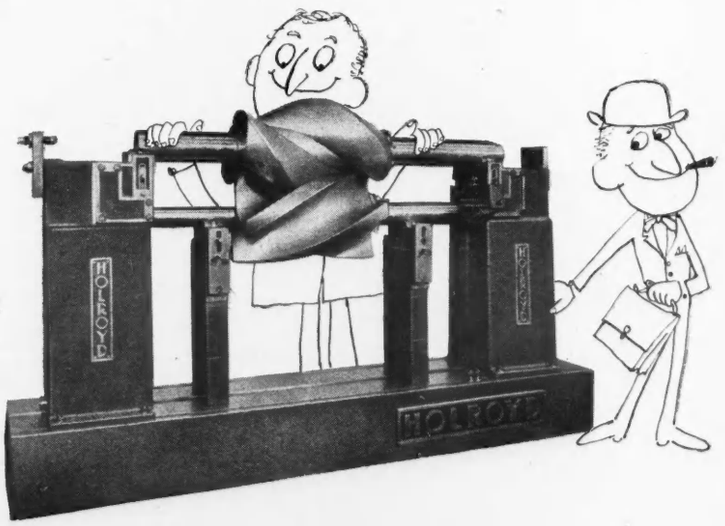

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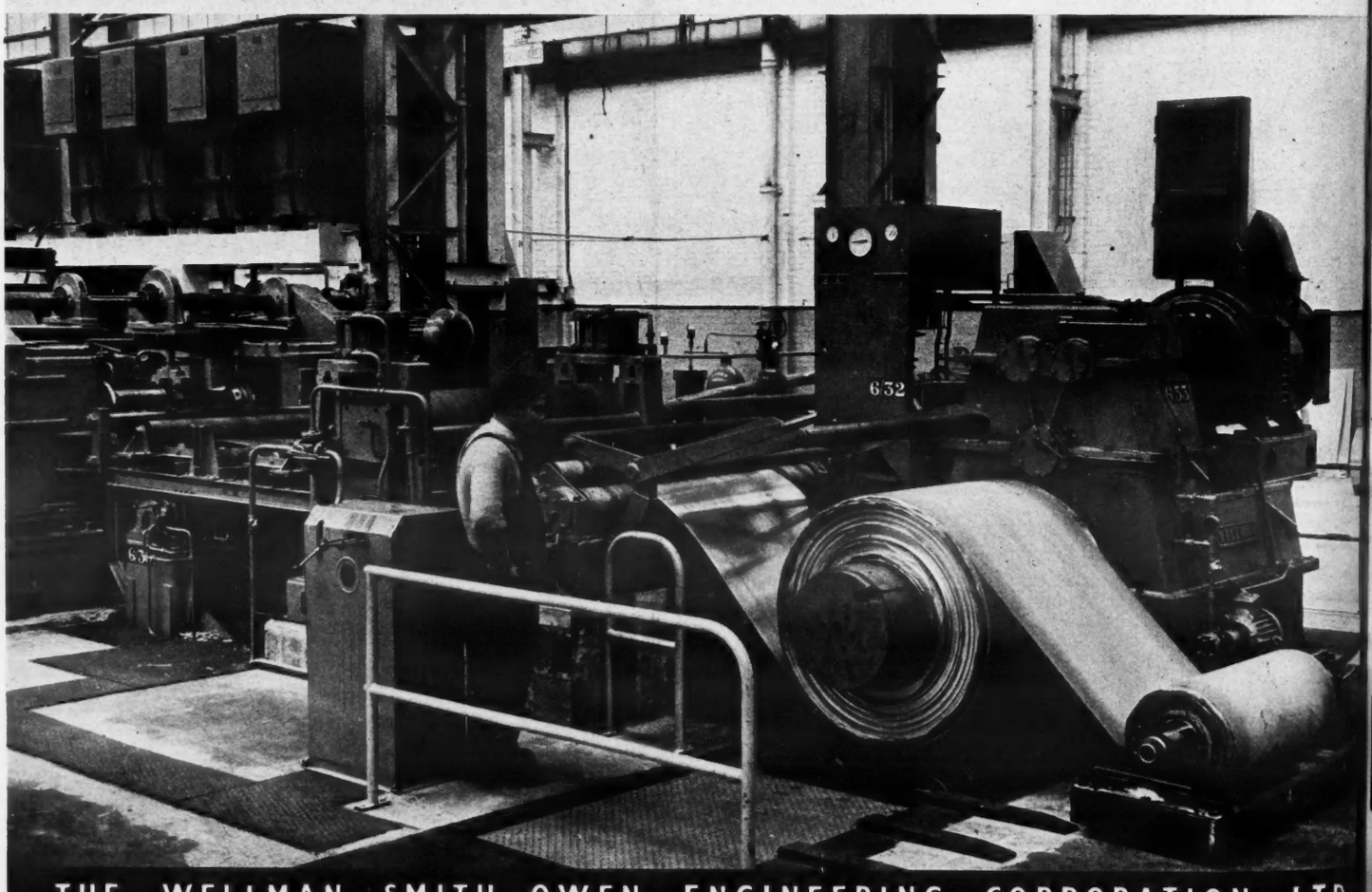

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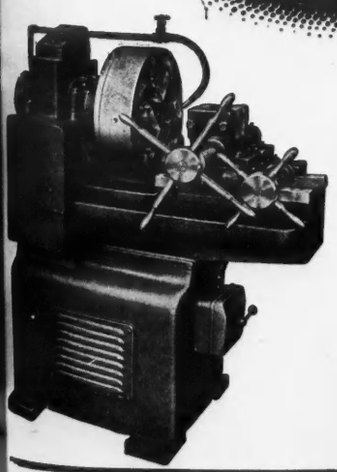

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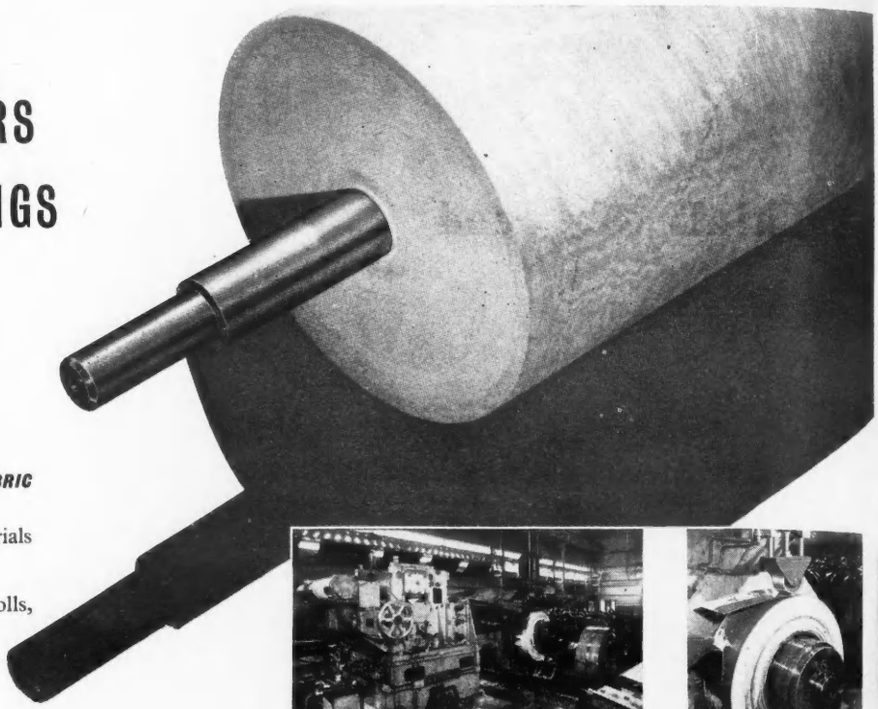

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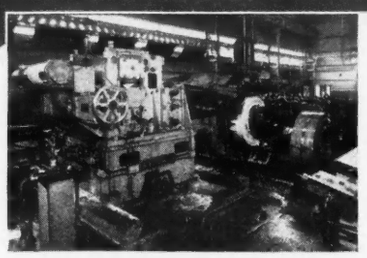

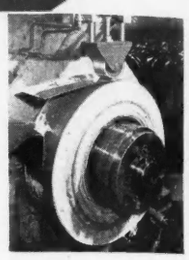

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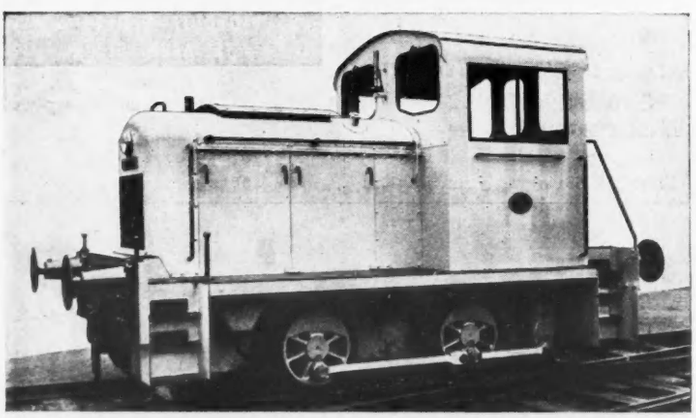

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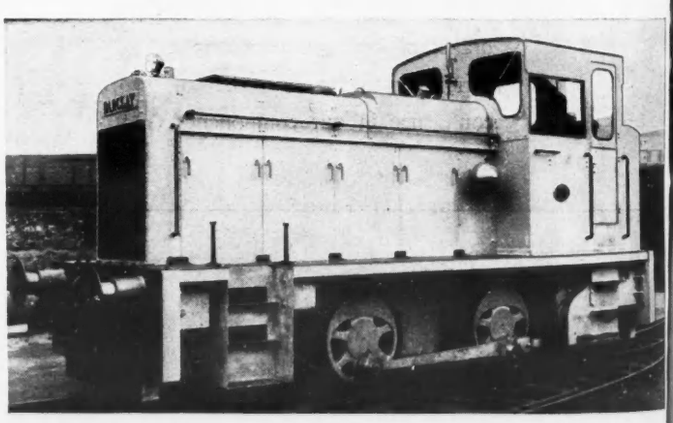

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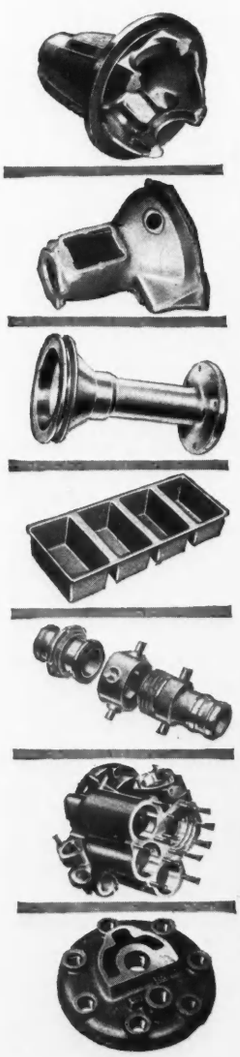

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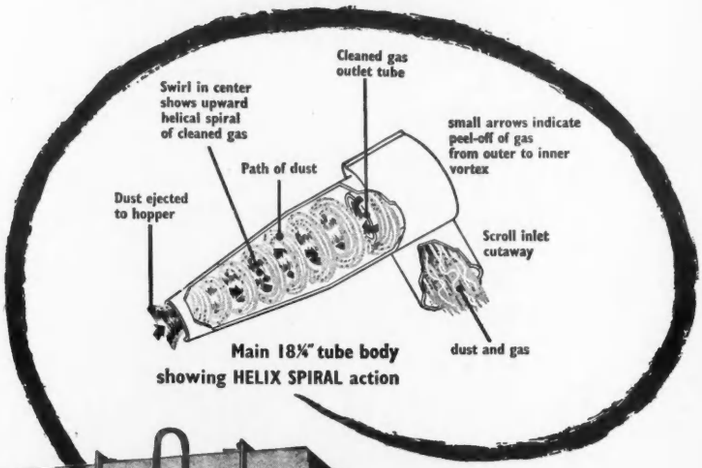
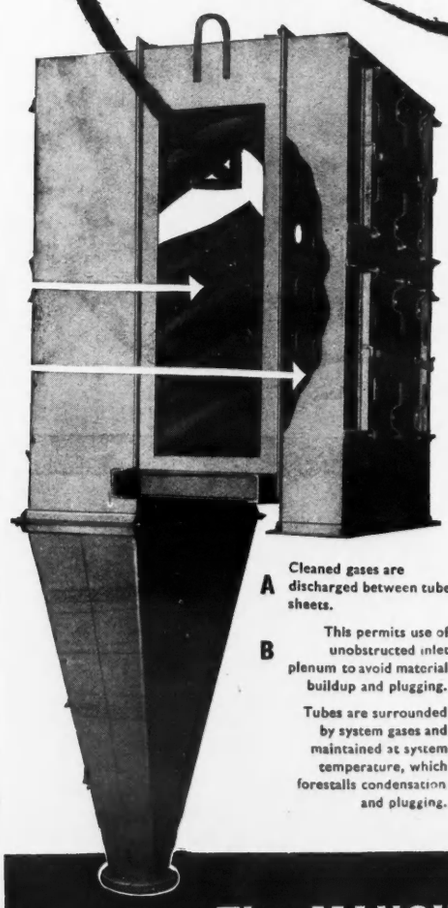

Cleaned gas outlet tube
Swirl in center shows upward helical spiral of cleaned gas
small arrows indicate peel-off of gas from outer to inner vortex
Path of dust
Dust ejected to hopper
Scroll inlet cutaway
dust and gas
Main 18¾" tube body showing HELIX SPIRAL action


A Cleaned gases are discharged between tube sheets.
B This permits use of unobstructed inlet plenum to avoid material buildup and plugging.
Tubes are surrounded by system gases and maintained at system temperature, which forestalls condensation and plugging.

A REVOLUTIONARY NEW UNIT-CAST DESIGN

This cutaway miniature cyclone tube from the tube bank of the new Mancuna-Dustex Collector shows why efficiency is so high and maintenance negligible. The scroll inlet establishes a velocity which is maintained through its powerful vortex—the dust travelling downward in an outer vortex to the hopper while the cleaned air moves upward in an inner vortex to the outlet tube for discharge between tube sheets. D-584 tubes are available in abrasion-resistant cast iron, non-sparking cast aluminium or stainless steel. Note the one-piece cast tube design with minimum ¼" wall thickness which increases tube life and performance.

The MANCUNA - DUSTEX D-584 MINIATURE CYCLONE COLLECTOR

MANCUNA ENGINEERING LIMITED,
Denton, Manchester. Tel: DENton 3965 (5 lines)
London Office: 59, Victoria Road, Surbiton, Surrey. Phone: Elmbridge 9793
SPECIALISTS IN GAS CLEANING AND DUST TECHNOLOGY.

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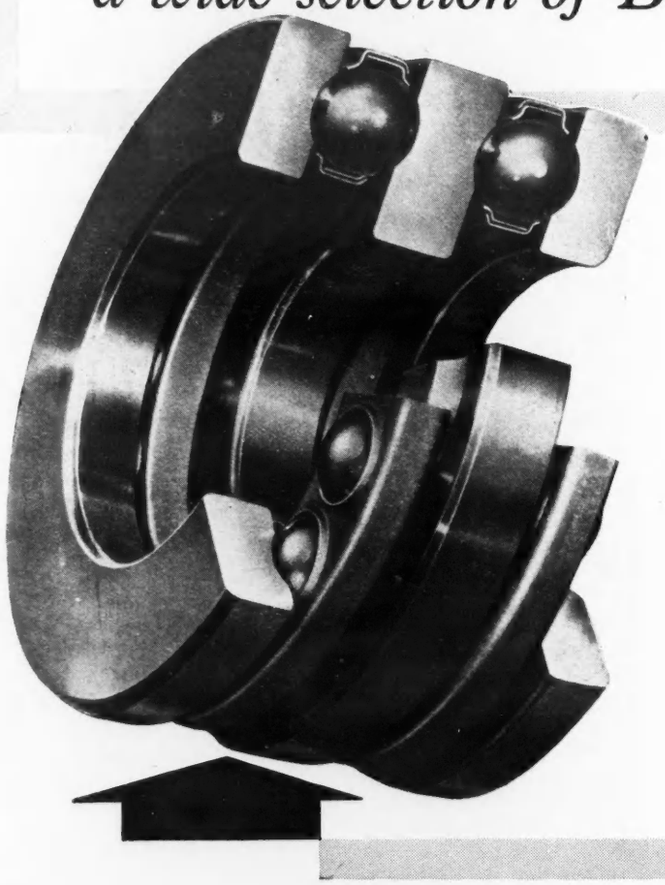
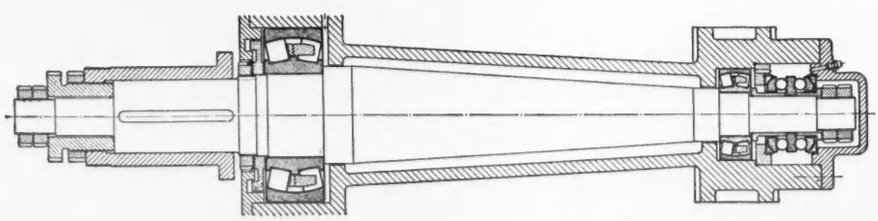
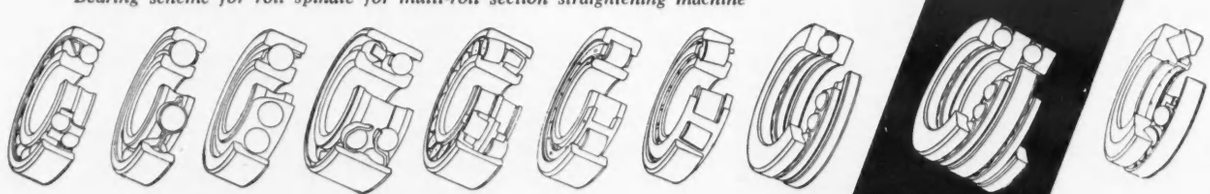


Where exclusively axial loads are to be dealt with acting in either direction, the double thrust ball bearing may be used. This bearing has two rows of balls, one for thrust in each direction. The centre ring is the shaft ring in metric sizes ; the housing rings may have either a flat or sphered seating. In inch sizes the centre ring is the housing ring.

This is one of the ten variants of the four basic rolling bearing types ; Skefko is the only British manufacturer making all four and can therefore offer completely unbiassed advice on the choice of bearing types for any specific problem.



Bearing scheme for roll spindle for multi-roll section straightening machine



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THE ENGINEER

No. 5456 AUGUST 19, 1960 Vol. 210

"DRAGON" IN EMBRYO

The first annual report of the O.E.E.C. "Dragon" high-temperature reactor was published last week. It deals with the first year's progress (1959-60) on the project and is reviewed at length on page 302 of this issue; but as the report is in every way an outstanding document some comment seems appropriate. In the first place the High Temperature Gas Cooled (H.T.G.C.) reactor experiment, which is, technically, the centrepiece of the "Dragon" project is remarkable in its own right. It represents a prodigious prospective development of the concept of the gas-cooled graphite moderated reactor to a stage beyond the Advanced Gas Cooled reactor, A.G.R.; indeed it may well mark the ultimate goal for this kind of reactor for power generation. It envisages the use of fuel element surface temperatures of about 1000 deg. Cent. and, therefore, for reasons of compatability, helium instead of carbon dioxide, as the coolant. The moderator is, in effect, impregnated with the fuel (which is partly fissile and partly fertile) and itself acts as the heat transfer surface, thus dispensing with the conventional canning material. The problems to be faced, including that of producing and fabricating a suitable grade of impermeable graphite, are sufficiently challenging and the possible rewards sufficiently attractive to make the whole experiment doubly exciting.

The scope of the "Dragon" project, however, covers more than the design, construction and operation of the 20 MW reactor experiment at Winfrith. It includes research and development in the whole field of high-temperature gas-cooled reactors and it is right that a project of this size should be carried out as a co-operative international enterprise. "Dragon" is truly a joint venture in which the provision of finance and technical manpower is being shared by "Euratom" and organisations from six other European countries — the United Kingdom, Austria, Denmark, Norway, Sweden and Switzerland. The main reactor experiment (H.T.G.C.) and the subsidiary zero-energy reactor "Zenith" at Winfrith are the first international nuclear research experiments to be located in Great Britain. Much of the associated research work, however, is being done by firms and other organisations on the Continent, as described in the O.E.E.C. report which, in itself, is a major piece of work—comprehensive, frank and full of interesting technical detail. Clearly the "Dragon" project has made an excellent start, with close and active collaboration between all the partners. Indeed the project might well serve as a model for the much desired co-operation that seems to be so difficult to achieve in wider spheres, both political and economic.

ON NOT BURNING COAL

From time to time it has been maintained in this country, and no doubt in others too, that to burn raw coal is so wasteful a proceeding that it ought to cease. Instead, it is suggested, all raw coal should be reduced to gas and coke, with extraction of the valuable by-products which serve as raw materials for the chemical engineering industry; and a proportion of the coal or coke and gas should be converted into oil by hydrogenation or the Fischer-Tropsch or some similar process, thus relieving the country of some of its need to import oil from abroad. For anyone not fully versed in the subject who has hitherto found such arguments convincing, a perusal of the report just issued by a Committee on Coal Derivatives, which was set up in April of last year by the Minister of Power, will act as a corrective. One conclusion, for instance, is that the "usage of coal as such for chemical processes (other than those based on the by-products of carbonisation) is about 1,500,000 tons a year, and, even if all existing and future synthesis gas and acetylene production were based on coal, the total demands for this purpose would be only about 2,500,000 tons a year in the late 1960's". As for oil from coal, "Even a cursory inspection of the cost data shows that hydrogenation of coal is a less economic route to oil synthesis than the alternative Fischer-Tropsch process; moreover, hydrogenation calls for specially selected coals of low ash content." Later in the report there is a study of the economics of the Fischer-Tropsch process. The starting material for that process is a mixture of carbon monoxide and hydrogen synthesised from coal. But "the difficulty in this country is that, even assuming much more efficient processes than are available at present, the cost of producing from coal synthesis gas suitable for the Fischer-Tropsch process would be about 7½d. per therm, while the value of the products which could be made from a therm of this gas would also be about 7½d." It is because the cost of synthesis gas amounts to about 70 per cent of the total cost of making oil from coal and because slagging gasifiers offer the best hope of reducing the cost of synthesis gas that the committee recommends the expenditure of a considerable effort on developing slagging gasifiers. But while it also recommends that work at Warren Springs Laboratory on the Fischer-Tropsch process should be tailed off, it suggests that basic work on catalysts and on the mechanism of the reactions between carbon monoxide and hydrogen, &c., should be continued, believing this work to be applicable in wider fields than the conversion of coal into oil alone.

The major derivative from coal, it becomes clear, must continue to be gas. Here the future is partly bound up with the changing demand for the other main product coke, though "carbonisation in more novel forms may well develop as a unit process in integrated complexes involving the manufacture of smokeless fuels together with gas or electricity." But "in anticipation of an extension in the demand for gas if its price can be reduced, the gas industry has been devoting increasing attention to methods for the complete gasification of either coal or oil which do not entail the simultaneous production of solid fuels." In that matter the committee comments, "New processes should show reasonable promise of producing town gas at not more than 10d. per therm including capital charges, if they are to be capable of replacing existing ones." The economics of producing gas by the Lurgi process attracts favourable comment but is seen to be connected with the ability to generate large volumes at favourable sites and therefore to require

the construction of a national gas grid possibly combined with underground storage. Further conclusions are listed on another page of this issue. It will disappoint a number of enthusiasts that the committee endorses the National Coal Board's conclusion that underground gasification of coal is not an economic process in this country.

PROGRESS OF SMOKE CONTROL

The Beaver Committee whose report led to the eventual passing of the Clean Air Act thought that a beginning could best be made towards making the country wholly smoke-free by tackling first what it termed the "black" areas. A Command Paper* which has just been laid before Parliament summarises in tabular form the progress which has so far been made in the establishment of smoke control areas in those regions and what plans exist for their extension. The publication relates only to England and Wales, not to Scotland or Northern Ireland. By the end of 1958 only some 120,000 premises within some 17,000 acres in the "black" areas were covered by smoke control orders. But by the end of 1963, if the programmes of the various authorities are fully carried out, some 2,250,000 premises and nearly 500,000 acres will be subject to smoke control orders, about the half-way stage in ridding the "black" areas of smoke. Planned completion dates at which each of the authorities' areas will be wholly subject to orders vary widely; but few lie beyond 1980 and some relate to the present decade.

But unfortunately there is no accepted definition of "black" areas. The Ministry made a provisional list of the authorities concerned, based upon a map annexed to the interim report of the Committee on Air Pollution, 1953. But of the 324 local authorities in England and Wales included in the list eighty-five in England have not responded to the Minister's invitation to submit programmes of domestic smoke control. Twenty-one of the eighty-five rejected the implication that they were within "black" areas; and thirty were in mining areas where the question of controlling domestic smoke is complicated by the issue of concessionary coal by the National Coal Board. The rest, numbering thirty-four, stalled for one reason or another, but it is not possible from the information given to assess with how much justification. In Wales and Monmouthshire only one out of a total of thirty authorities approached submitted a programme! Most of them seemed to consider that they were not in "black" areas, a response which may reflect the relative smokelessness of much of the house coal used in those regions. It seems clear from these figures that although many local authorities are keen to press on with smoke control, others are less enthusiastic and some perhaps disinclined to move at all. There is also evidence, unfortunately, that actual progress in the creation of smoke control areas is falling well behind plans in some regions and to some degree in almost all of them.

UPPER ATMOSPHERE ACHIEVEMENTS

We are delighted to be able to congratulate the Americans upon a remarkable set of achievements in upper atmospheric experiments last week. These different achievements all stemmed from ambitious and tenaciously sustained engineering enterprises. Likely to become historic was the recovery intact for the first time on record of an object that had completed a number of orbits. As long ago as July, 1957, those carrying out that very ably and economically engineered project "Vanguard" were fully ready to consider the problem of plunging their little satelite back through the atmosphere, if only someone else would solve the problem of finding the object after it landed. Three years later, the order of difficulty is obviously much the same: it is worth remembering that at least one of the many preceding capsules was lost because the "Agena," which "can neither love nor promise nor forgive," obeyed meticulously instructions in the transmission of which a human operator erred. The Lockheed "Agena" must be one of the most refined and reliable tools among the multitude that serve modern science, and its abilities to stabilise itself in free fall and to break out of orbit predictably should guarantee this vehicle a future as well as a place in history. Another evident triumph of painstaking development is the setting into orbit of "Echo 1." Its orbit would gladden the hearts of those Greek mathematicians who preached the essential rightness of the circular path; and its successful launching encourages confidence in the prospects of setting up useful satellites for communications relay, missile detection, and weather survey purposes. "Echo 1" vindicates again a suggestion, first made in this country, that a large diameter but light satellite could be created by inflating a balloon-like object after launch into orbit. Another demonstration of delicacy of control, but this time on the part of a decision-making animal, was a "zoom" climb of the rocket-propelled North American "X-15" to a height where "flight" is normally the prerogative of balloons: in fact, it is not clear whether or not the aircraft did sustain acceleration of or exceeding *g* when at the altitude quoted. The "X-15" is a, perhaps, needed reminder that an orbit is still very, very expensive of attainment, for even with an air launch and the use of advanced, if not exotic, propellants this craft still remains thoroughly earthbound. A worthwhile reminder of what can be done by making the very best use of severely circumscribed capabilities came with yet another accurate 5000-mile flight by that oldest of all the large rockets, the "Atlas." By virtue of a clever assessment of the relative importance of the host of conflicting requirements in the design of a rocket missile, leading to the so-called $1\frac{1}{2}$-stage construction, and resulting in a structure that will not support itself except in flight, Convair Astronautics have achieved a combination of long range with accuracy at a price that the customer can reasonably afford.

ABNORMAL LOADS BY ROAD

Within the last year or two much concern has been expressed in Parliament and elsewhere about the use of roads for conveying very large and very heavy loads from manufacturers' works to their destinations. Such loads, necessarily moving slowly and taking up a lot of road space, frequently create congestion and sometimes, even though there is a police escort, add to road dangers. It is, of course, much too facile to suggest that such abnormal loads ought always to go by rail. It would be physically impossible for the railways to carry some of them owing to limitations imposed by their loading gauges, whereas on the roads, providing care is taken to plan the route to avoid low or weak bridges, narrow streets and the like, almost anything however large and heavy can be conveyed from one place to another. Alternatively, it is suggested, such large objects ought to go by sea. But quite apart from the fact that there are limitations on what a cargo ship can accommodate, there is the difficulty that not all sites to which indivisible loads are to be carried are close beside docks, nor are the works in which they are made. Thus even if the movement is

* "Smoke Control (England and Wales)." H.M. Stationery Office. Price 3s. net.

carried out by sea some of the journey may need to be made by land with the consequent need to transfer the load from ship to road vehicle or vice versa, an inconvenient and expensive expedient. It does not seem, therefore, either reasonable or expedient altogether to ban the movement of wide, heavy, and lengthy loads by road. But it is surely reasonable that some restrictions should be imposed. For although to the firm concerned it may be cheaper to design some object for manufacture as one outsize piece and then to convey that object to its destination wholly by road, the cost to other people through the road delays they may suffer should be taken into account.

No doubt as a consequence of the number of complaints that have been uttered a number of firms associated with the movement of large loads by road have, we understand, been approached by the Ministry of Transport to comment upon certain amendments to the Motor Vehicles (Authorisations of Special Types) General Order which it is proposed to make. We gather that it would become illegal to move under the General Order engineering plant weighing more than 150 tons or exceeding 80ft. in length or 20ft. in width, though the Minister would be empowered to make special orders covering such movements. Another of the Minister's proposals, we believe, is that before any vehicle wider than 14ft., with or without its load, can be moved by road it will be necessary to inform the Ministry, whose consent it will be necessary to obtain. In granting or withholding consent the Minister will, of course, take into account the possibility of moving the load by rail or sea. Additionally, we gather that under the proposals the movement of any load including its vehicle exceeding 80ft. in length will require authorisation by the Minister and for the movement of any vehicle (or load) exceeding 40ft. in length or the movement of any load or load-carrying vehicle and other vehicles in combination exceeding 75ft., the police will need to be notified. The adoption of these proposals would necessitate a change of the Regulations governing the movement of indivisible loads.

We see little reason to object at all strongly to the proposed changes under the General Order if they are in truth as represented to us. But we have heard something about changes to the Regulations which sounds less satisfactory. We have the impression, for example, that after the Ministry has signified its approval of the movement of a wide load by a given route it will still be necessary, as at present, to notify the police (and highway and bridge authorities should the weight of the object require it). But should the police or one of the authorities specify some change in the proposed route it will be necessary to make a renewed application to the Ministry. There is inherent in such an arrangement the possibility of peculiarly irritating delays developing should the Ministry and some police authority get at loggerheads. No doubt the firms consulted will have drawn the attention of the Minister to this point. If the scheme is to be workable the Ministry will need to recognise the need for haste in making up its mind. We understand that it would hope to notify any firm concerned, within a day or two of receiving an application to move a load, of its approval; of its opinion that sea transport should be used (necessitating the subsequent presentation by the firm if it still felt it necessary to move the load by road of very convincing reasons for choosing road transport); or of the likelihood of delay when the examination of any given proposal appeared to need some time for further consideration. Are we incorrect in getting the impression that some pressure might be brought to bear to get firms to redesign certain products to be divisible into loads of smaller size?

GAUGE AND TOOL MAKERS' EDUCATIONAL TRUST

Particular interest attaches to the announcement that a body to be known as the Gauge and Tool Makers' Educational Trust is being established by the Gauge and Tool Makers' Association. Amongst the broadly stated objects of this trust will be the provision of funds for grants to be awarded for the furtherance of technical education of apprentices and students in the gauge and tool industry, promotion of the study and knowledge of the products covered by the industry, and the establishment and support of concerns associated with the objects of the trust.

The setting up of this trust is indicative of the growing appreciation by responsible bodies of the assistance which must be given to assure that younger members entering an industry should receive the fullest encouragement to attain the highest qualifications and breadth of knowledge essential to the future wellbeing of both the individual and his industry. Over recent years considerable developments have been made in gauge and tool making practice and the industry has increasingly become that of the specialist rather than the generally trained man with a "flair". There is little doubt that if the objects of the trust are achieved it will perform a service of lasting benefit to the industry and those who work in it.

The Engineer—100 Years Ago (AUGUST 17, 1860)

"PROGRESS OF THE METROPOLITAN RAILWAY"

"The rapidity with which the works of this railway are being pushed on by the spirited and confident contractor, Mr. Jay, is a matter no less for surprise than congratulation. The general public hear but little, and see nothing, and there is a shadow of an opinion floating about that the works are stopped, and that the whole affair is in a state of postponement. That there is no ground for such an opinion was sufficiently evidenced to a small party of citizens who visited the works on Wednesday last, for the purposes of an inspection.

"The party were conducted from the Great Northern terminus direct into the tunnel which connects the Great Northern with the Metropolitan, which tunnel, thanks to Mr. Jay, is already completed. The junction commences with the Great Northern Railway near the entrance to the first tunnel on that line, and runs from there to King's-cross, which is a distance of about one-third of a mile. This branch is constructed with a tunnel for nearly the whole of the distance, and running under the surface of the road in Maiden-lane. In the construction of this branch two very important works occur, the one is, adopting means to carry the main Fleet sewer ; and the other, in the formation of a groin, where the lines will diverge four different ways, leading into the main line, and all radiating from one centre. For the purpose of carrying the Fleet sewer in its original course, it was necessary to construct it immediately over the tunnel of the railway. This has been done by using massive iron tubes running through the crown of the arch. To execute this was a work requiring great caution and skill, particularly as the floods at that time were very high and rapid, which made the operation more dangerous and difficult ; but the whole of these difficulties were successfully overcome, and this interesting piece of work is now in a state of completion. That portion of the work which is now in active progress is the commencement of the main line near King's-cross.

"There is a general opinion abroad that the line will be wholly underground, which, however, is an error likely, if left uncorrected, to prejudice the enterprise. From King's-cross to the City the line will be subterranean only where it passes under roads or important buildings which cannot be removed. Elsewhere, it will be open to the daylight and the fresh air, and will be simply a cutting, and not a tunnel. As before remarked, the works are being pushed on with extraordinary vigour, and in less than twelve months the line will be complete as far as Euston-square, and, in the other direction, with the City. The chief weight of the enterprise has fallen on Mr. Jay."

"Dragon" High-Temperature Reactor

No. 1

The first annual report of the O.E.E.C. High-Temperature Reactor Project known as "Dragon," published last week by the European Nuclear Energy Agency, gives a very detailed account of progress in 1959–60. *"Dragon" is a joint venture; its main objectives are to investigate the high-temperature gas-cooled (H.T.G.C.) reactor system and, specifically, to design, build and operate a 20MW (thermal) H.T.G.C. reactor experiment at the U.K.A.E.A. Establishment at Winfrith, Dorset. The illustration on the right shows the foundation slab of the reactor experiment and the following article is based on extracts from the report.*

IT may be recalled that the "Dragon" project was originally proposed at a meeting in March, 1958, organised by the European Nuclear Energy Agency (E.N.E.A.) to study the most promising means whereby O.E.E.C. countries might collaborate in work on experimental and prototype reactors. The main reason for this proposal was that the U.K.A.E.A. in its longer term development of the gas-cooled graphite-moderated reactor for power production had, for nearly three years, been investigating the possibilities of such a reactor operating at very high temperatures.

Having considered the technical aspects of the British proposal the E.N.E.A. committee recommended that it should be adopted as the basis for a joint European project, which should not, however, be limited to a single reactor experiment but should include research leading to a wider knowledge of high-temperature gas-cooled reactors.

As a result the "Dragon" agreement was signed in Paris on March 23, 1959, by representatives of the United Kingdom Atomic Energy Authority, the Republic of Austria, the Danish Atomic Energy Commission, the "Euratom" Commission, the Norweigian Institutt for Atomenergi, the Swedish AB Atomenergi and the Government of the Swiss Confederation.

The "Dragon" Project has two main aims: the first is to carry out a research and development programme connected with the high-temperature gas-cooled reactor system; and the second is to develop, design, build and operate a 20MW (thermal) high-temperature gas-cooled reactor at the Atomic Energy Establishment at Winfrith, Dorset.

General direction of the whole project is vested in a board of management consisting of representatives of all the signatories and of E.N.E.A.; the present chairman is Dr. Sigvard Eklund (Sweden). The chief executive of the project, Mr. C. A. Rennie (United Kingdom), acting in consultation with a general purposes committee of specialists from participating countries, is responsible to the board for the technical and administrative conduct of the work. The project is organised into three divisions: they are research and development under Dr. L. R. Shepherd (United Kingdom); engineering under Dr. G. Franco ("Euratom") and administration under Mr. R. K. Andresen (Norway).

At the end of the first year's working the staff of the project totalled 188, consisting of fifty-five overseas, and 133 seconded from the U.K.A.E.A., including seventy-four scientists and engineers.

The total estimated expenditure on the "Dragon" Project is £13,600,000 over the five years of the original agreement. Of this sum £10,000,000 is to be shared between the signatories as follows: U.K.A.E.A., 43·4 per cent; Austrian Republic, 1·85 per cent; Danish Atomic Energy Commission, 2·0 per cent; "Euratom," 43·4 per cent; Institutt for Atomenergi, 1·65 per cent; AB Atomenergi, Sweden, 4·4 per cent; Switzerland, 3·3 per cent. Any additional expenditure, up to £3,600,000 will be borne by the U.K.A.E.A. to which any reactor experiment and installations or equipment built or acquired under the joint programme will belong at the end of the five-year period. The budget approved for the first year of the project was £775,000. The project budget for 1960-61 is £2,830,000, including £950,000 for the reactor plant and buildings, £910,000 for extra-mural research and development and £970,000 for the maintenance and work of the project staff at Winfrith. Over the five-year period the total cost of the construction of the reactor experiment is estimated at £6,400,000.

During the first year of the project, the original basic design for the experimental reactor at Winfrith has been extensively studied, both theoretically and experimentally, and it is now considered as frozen on all aspects which could fundamentally influence the building and civil engineering design.

Civil construction work at Winfrith on buildings and plant external to the reactor began in 1959, and important contracts approved up to March 31, 1960, included those for opening up the reactor site; construction of the pressure vessel, thermal shield tanks and the containment building; the assembly of a high-temperature seven-fuel-element experimental plant; and the development and manufacture of impregnated graphite.

Civil engineering work for the reactor was started on April 27, 1960. The following works will be carried out by Turriff Construction Corporation, Ltd., Budbrooke Road, Warwick: the construction of the main reactor building, four other major buildings, and ancillary buildings, connecting links, service ducts, drainage, and the completion of the roadway layout. A preliminary or "opening-up" contract has already been carried out by Turriffs for the foundations of the reactor buildings and the initial stages of the roads and services, including the approach road from the main area of the Winfrith A.E.E. site.

For the foundation slab of the reactor building it was necessary to excavate a circular hole approximately 40ft deep and 120ft diameter at the bottom, through the peat, silt, sand and clay pockets which lie below the surface of this part of Winfrith Heath. To keep the area of disturbed ground to the minimum, the sides of the excavation were dug to the steepest batter that would stand unsupported with safety in such ground (50 deg.), giving a diameter at the top of the hole of nearly 200ft. The hole and foundation slab are illustrated at the top of this page.

The greatest physical difficulty of construction work on Winfrith site has been the presence of ground water in considerable quantities just below the surface, which necessitated the extensive use of well-point dewatering for all excavation except the very shallowest drains and foundations. By siting the "Dragon" reactor on a relatively high area of the heath it could be anticipated that ground water would not be met until a much greater depth had been reached. In the trial bore-holes this was found to be at about 28ft, and the method of excavation was planned accordingly.

Well-points 18ft deep were installed at 7ft 6in centres below a berm formed at 27ft before excavation was carried below this level, and two dewatering pumps, delivering a total of about 100,000 gallons per hour, lowered the water table just ahead of the excavation, and kept the bottom dry for the time that it was exposed.

The saucer-shaped base of the excavated hole was blinded with a layer of weak concrete, into the centre of which was embedded, at a ceremony on April 27, 1960, a stainless steel cylinder containing coins of the O.E.E.C. countries, and documents com-

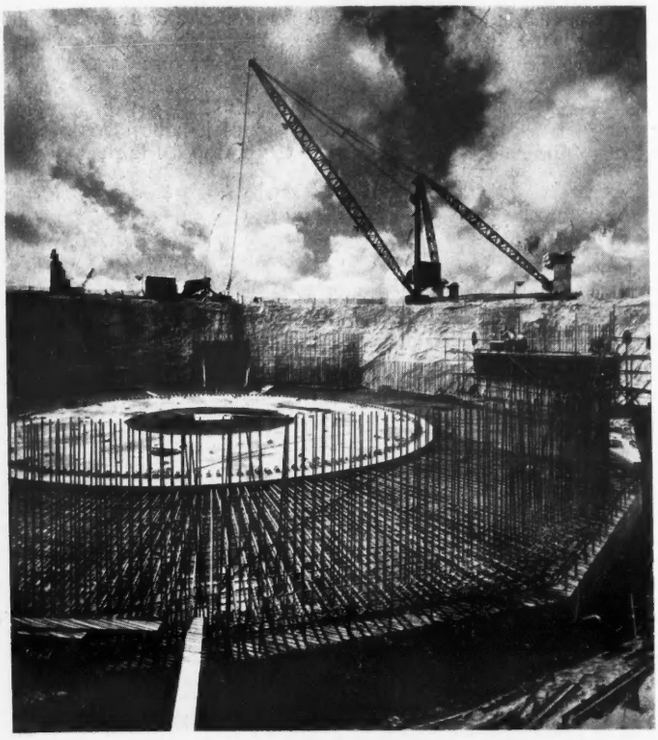

Fig. 1—Reinforced concrete foundation slab for the " Dragon " high-temperature gas-cooled reactor experiment at Winfrith, Dorset

memorating the occasion. On top of this was poured the twelve-sided main foundation slab, 12ft thick in the centre, in three layers, each containing several " mats " of heavy steel reinforcement as shown in Fig. 1.

The slab is extended on the west side to form the base of the peripheral services duct, and on the north side as the foundation of the vehicle air lock, which will give access to the reactor building at ground level. Also incorporated in extensions of the foundation slab are two of the anchors for the guy ropes of the 100-ton pole derrick crane which will be used to lift the reactor core itself and other heavy components into the building over the top of the 90ft high walls of the containment structure. Excavation for the foundation slab was commenced on March 24, 1960, and placing of the concrete was completed on July 18, two weeks ahead of the programme.

The main item in the new contract is, of course, the main reactor building. It is a cylindrical structure with a domed roof, 110ft diameter and 110ft 6in high above foundation slab. The exterior shell is formed of two concentric reinforced concrete walls 15ft apart and generally 2ft thick, and a domed roof of reinforced concrete 15in thick, containing an " umbrella frame " of heavy steel beams, and lined on the soffit with steel plate. In the space between the two walls are the numerous cells on five floor levels, which contain cooling plant and control points for operating the reactor and watching its functioning through radiation-proof observation panels. A special requirement on this concrete structure is that the containment consisting of the outer wall and roof is to be made to withstand a specified air pressure without significant leakage.

Normally this condition of reactor design is obtained by the use of a welded steel outer containment, such as the sphere which encloses the fast breeder reactor at Dounreay, but for " Dragon " the structural concrete itself is to be made to fulfil this function. Although the technique of making concrete waterproof has been perfected long ago, very little is known of the factors which will ensure its airtightness, and practical experience is limited to work done during the last year or two in other establishments of the U.K.A.E.A. Nothing on the scale of the " Dragon " containment has ever been attempted before, and this part of the concrete construction will in itself constitute a significant item of research.

Immediately inside the inner of the two cylindrical concrete walls is the inner containment of welded steel construction, the subject of a separate contract. Inside this again is another concrete construction, consisting of the support for the reactor core, which combines a biological shield of 5ft 9in thickness of concrete of guaranteed density. This is continued above and over the reactor core and charging machine, with portions made removable for access or modification at any time. Between the core structure and the steel containment are a ring of cells formed in reinforced concrete, to house the fuel storage and handling equipment, primary and secondary heat exchangers and further inspection and experimental facilities. Some parts of the walls and partitions are in barytes concrete or iron shot concrete, where the extra protection afforded by these materials is necessary.

The other buildings (Fig. 2) on the " Dragon " site, while comprising a major proportion of the contract value are, however, of more conventional construction. Externally the walls are clad with vitreous enamelled steel sheets and patent glazing ; internal linings and partitions are mainly of brickwork. The largest of these is the services building, containing an electrical substation, with all necessary control gear, workshops, boilerhouse, and offices. The structure is partially steel-framed with concrete walls and roof.

The control building, partly two storeys and partly three storeys high, has, besides the main control room, the administration offices, instrument rooms and workshops, various stores, and the change-room accommodation. Access to the reactor building is by elevated covered way at first floor level. Between the reactor building and the storage building (with its office annexe) there is an enclosed way which can be used by vehicles. A separate building houses the main cooling plant for the reactor, and there are the usual layouts of drainage delay tanks and fuel tanks for the domestic heating boilers. The main buildings and tank areas are connected by underground services ducts, large enough for adequate access to the many cables and pipes which they will contain, and there are three (in places four) separate systems of drainage covering all areas of the site.

Contracts for two other items of the " Dragon " project have been awarded to Turriffs. The project design office was the subject of a package contract, the first phase of which was carried out from April to September, 1959, to give accommodation for the O.E.E.C. design team by October 1, and the second phase from January to July, 1960. A project technical building consists of a three-storey office block of precast concrete " waffle " slab construction connected to a steel-framed engineering hall containing rig bay, services hall, and laboratories. Erection of the office block began at the end of May, and of steelwork for the engineering hall during the last few days. The whole building is due for completion at the beginning of February, 1961.

H.T.G.C. Reactor Experiment

In the " Dragon " high-temperature reactor it is intended to extend the technology of

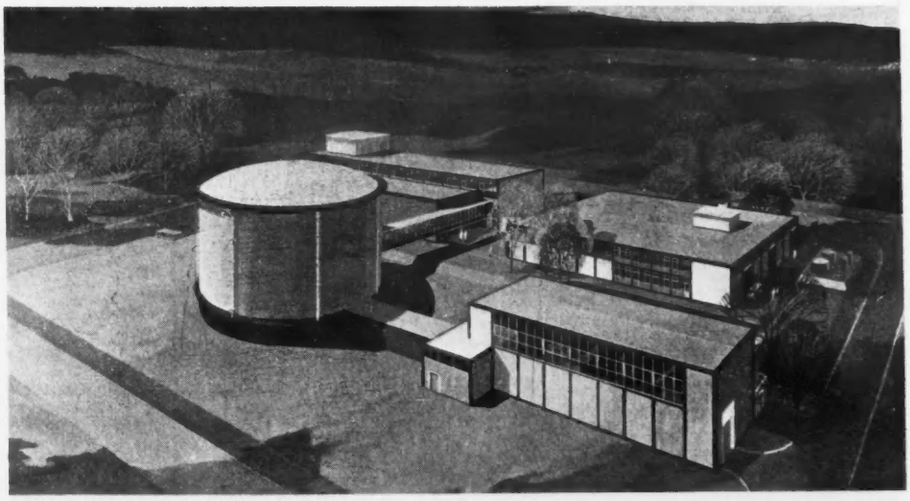

Fig. 2—Artist's impression of " Dragon " reactor and associated buildings at Winfrith. In the foreground are reactor building (left) and storage building (right). Behind the reactor is the main building, with the service building and the delay tanks on the right

the gas-cooled graphite-moderated system beyond the limitations of the Advanced Gas-Cooled Reactor, by achieving a higher heat rating per unit weight of fuel and a higher outlet gas temperature.

To do this it is proposed to use an all-ceramic fuel element consisting of a " can " of graphite surrounding a graphite sleeve or rod which is impregnated with fuel, thus making the moderator serve as the heat transfer surface. The primary fuel is highly enriched uranium-235, but the net consumption of fissile material can be reduced by including in the fuel some thorium for conversion, by irradiation, into uranium-233 which is fissile.

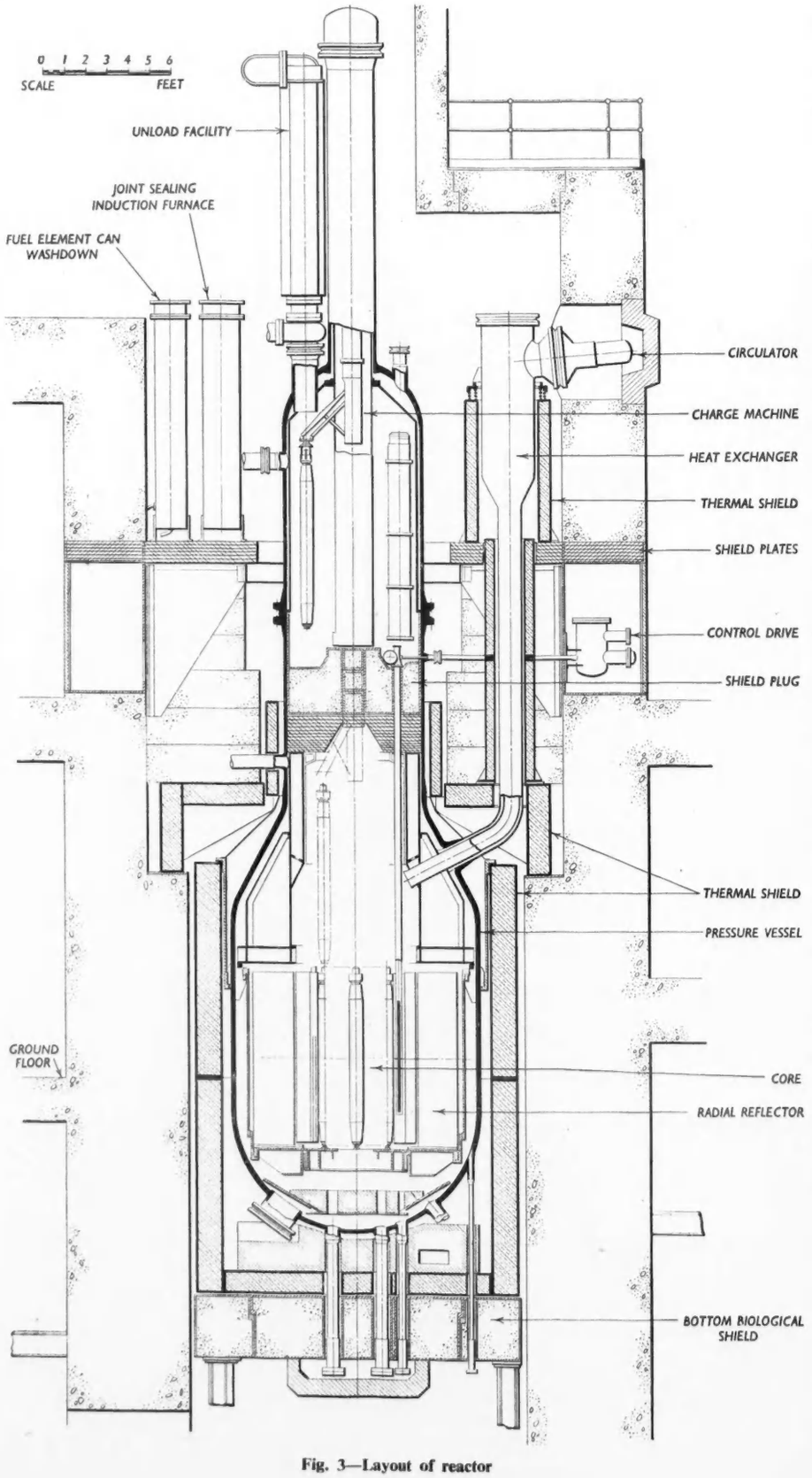

Fig. 3—Layout of reactor

Another technological advance will be the use of helium as the coolant. As shown in the table, the outlet temperature of the helium coolant is 750 deg. Cent. The choice of coolant pressure (20 atmospheres) has been mainly dictated by design considerations but it is expected to correspond fairly well with

Main Particulars of " Dragon " H.T.G.C. Reactor

Thermal output	20MW
Coolant	Helium
Pressure	20 atmospheres
Inlet temperature	350 deg. Cent.
Outlet temperature	750 deg. Cent.
Maximum exit temperature from hottest channel	926 deg. Cent.
Total mass flow	4·35 lb/sec (9618 g/sec)
Reflector	Graphite
Overall height	8ft (224cm)
Overall diameter	9·5ft (29cm)
Core :	
Equivalent diameter	3·5ft (107cm)
Equivalent length	5·25ft (16cm)
Mean power density	14MW per cubic metre
Cooling channel voidage	13 per cent
Mean heat flux over fuel element surface	24W per sq. cm.
Number of fuel elements	Thirty-seven
Number of fuel element rods	259
Fissile loading, ^{235}U	20 kg
" Breeder " loading, ^{232}Th	134·8 kg
Mean heat rating of fuel rod	482·6W per sq. cm
Pressure vessel, nominal dimensions :	
External diameter (over core)	11ft 6in
Internal diameter of upper neck	6ft 3in
Thickness of main vessel	2¼in
Thickness of lower neck	1¼in
Thickness of upper neck	⅝in
Total internal volume	2240 cubic feet

that which might be obtained in later power reactors and should, therefore, provide valuable experience from the standpoint of primary circuit problems.

The behaviour of the core of the reactor under normal operating conditions is naturally one of the main points of interest in the reactor experiment ; here, the main consideration has been that the conditions should be at least as severe as in later power reactors with particular regard to heat fluxes, material temperatures and fission rate inside the fuel. Before the " Dragon " Project, the proposed operating power of the reactor experiment had been 10MW, corresponding to a heat output density of 7MW per cubic metre of core. This figure appeared to be low and would have resulted in a rate of accumulation of fission product and consequent damage in the fuel which would have been too small to yield useful information. By raising the power to 20MW and thereby doubling the heat output density it should be possible to obtain, in two years' operation at full power, the experience and information needed to specify the charge of a future power reactor.

Two other related factors are of importance, namely, the neutron flux or fuel rating and the duration of the fuel cycle. There are obvious reasons for desiring both of these to be as high as possible, so that the fissile investment should be burned as quickly and completely as possible. However, theoretical studies demonstrated that some compromise would be necessary between heat output density, neutron flux and fuel lifetime. It was decided that the heat output density should be kept as high as possible but that some sacrifice should be made in the value of the neutron flux in order to give a high total burn-up or lifetime for the fuel. This amounted to selecting a rating of 1MW per kilogramme invested uranium-235, that is to say, the fissionable charge of the reactor experiment will be 20 kg of uranium-235. A higher rating would have been preferred, but it was found that this would have led to considerable difficulties in obtaining a sufficiently long fuel lifetime.

It is intended that the fuel should have the maximum possible capacity for retaining fission products in order to reduce the demands on the coolant processing plant. The introduction of fuel boxes may help in this respect by introducing a significant delay in the release of fission products into the purge stream. At the same time the process-

ing plant will be designed with the highest possible capacity and it should be possible to introduce one or two experimental fuel elements with enhanced emission to study the problems of " de-poisoning," since the latter may be regarded as one of the objectives of high-temperature reactor development. Although no experience was obtained in irradiation of fuel boxes during the past year, specimens were prepared and irradiations started.

The reactor is illustrated by sectioned elevations in Figs. 3 and 4.

Surrounding the upper part of the reactor vessel are six parallel and self-contained branch circuits each carrying a vertical primary heat exchanger and a gas-bearing circulator unit, heat being transferred through secondary circuits into tertiary heat disposal circuits. Several alternative schemes for the secondary circuits are being considered. The general arrangement of each scheme is similar, but further study is necessary before a final choice can be made.

Because the coolant gas in the primary circuit is active, a great deal of thought has been given to systems with double-wall heat exchanger surfaces to minimise the possibility of active gas leaking into the secondary circuit, the intention being to monitor a common space connecting the inter-surfaces for leakage. However, the main conclusion is that double-wall tube systems introduce many stress complications and manufacturing uncertainties, whilst the use of single-wall tubes produces more reliable engineering with better opportunities for testing during manufacture and, consequently, less likelihood of subsequent leakage. The use of single-wall heat-exchanger tubes is also more in keeping with the needs of subsequent power producing systems where the maximum heat exchanger efficiency will be sought, and by employing this method in the reactor experiment, useful information and experience will be obtained.

The possibility of active gas leaking into the secondary circuit is covered by building the whole secondary circuit within the reactor containment shell. This shell surrounds the whole reactor and encloses the complete primary circuit and its branches, together with connected circuits which could become active as a result of inter-leakage. A shield wall is built around the shell so that it forms an enclosure which may be used as a hot cell for the removal of active components. The shell itself will contain any active gas which has leaked from the pressure vessel or connected equipment. The containment standards of the pressure system limit the quantities of leakage gas and a system of controlled venting maintains a safe equilibrium level within the enclosure. The shell is designed to stand a pressure in excess of that demanded by safety considerations, and the main reactor building, surroundings and containment shell are designed to provide a final enclosure. This building provides an annular working space for control of operations such as the charge-discharge process. It also houses ancillary plant, electrical distribution equipment, ventilating and air-conditioning plant. Normal ventilation is through open inlet and extract ducts, but if necessary the building may be closed and a controlled extract taken to a high level release point at the top of a ventilating stack.

It will be noticed from Fig. 3 that the outer regions of the reflector consist of a static graphite stack, whilst the region immediately surrounding the core consists of live vertical columns arranged in two concentric rings. By using the excess pressure of the inlet coolant these columns apply a closing force, clamping the top ends of the fuel elements together. The outermost ring of columns contains keying devices to limit restriction that would cause short circuiting of the coolant. The inner ring which can be removed by the charge machine contains the channels in which the absorber control elements are suspended.

To allow for the structural items to be assembled after installation of the pressure vessel, the parts are subdivided into units which will pass through the neck of the vessel. Other points of interest about the core structure are the use of skirt-type spigot rings to prevent thermal movements from applying unwanted stresses in adjacent members ; the spigots also give permanent concentricity to the whole core.

In general the reactor building consists of an inner steel shell 66ft in diameter and approximately 81ft high, surrounded by an outer building of concrete construction. The inner building is designed as a hot cell surrounded by a concrete shield wall which is part of the outer building. The steel shell is designed to withstand an internal pressure of 10 lb per square inch gauge and an external pressure of 0·25 lb per square inch gauge. It will normally be at approximately atmospheric pressure and will contain nitrogen to eliminate fire hazards. The internal pressure is controlled, but for protection vacuum relief valves are provided. The admission of air due to limited operation of gas lock doors can be accepted. At the design pressure a leak rate of 0·1 per cent of building volume per day is specified.

The outer building is also designed as a sealed building, with a specified leak rate of 5 per cent per day at 1 lb per square inch gauge. The design pressures are 3 lb per square inch gauge internal pressure and 2 lb per square inch gauge external pressure. The building would normally operate with an internal pressure at atmospheric level or very slightly less. Loading differing from normal would usually be due to barometric changes. Ventilating air enters and leaves the outer building through gas valves which can be closed in the event of an incident. Air is normally exhausted into the ventilating stack via filters.

The storage building is designed mainly for the storage of new and irradiated fuel elements and for other equipment removed the reactor. It forms a parking area for handling vehicles and shielded trollies and it contains an area where slightly active components may be washed down and serviced. Items of significant activity can be stored in their shielded trolley prior to transit from

Approximate flow distribution :
A—14 per cent through control elements.
B—14 per cent between live and fixed reflector.
C—20 per cent through fixed reflector.
D—52 per cent over outside reflector diameter.

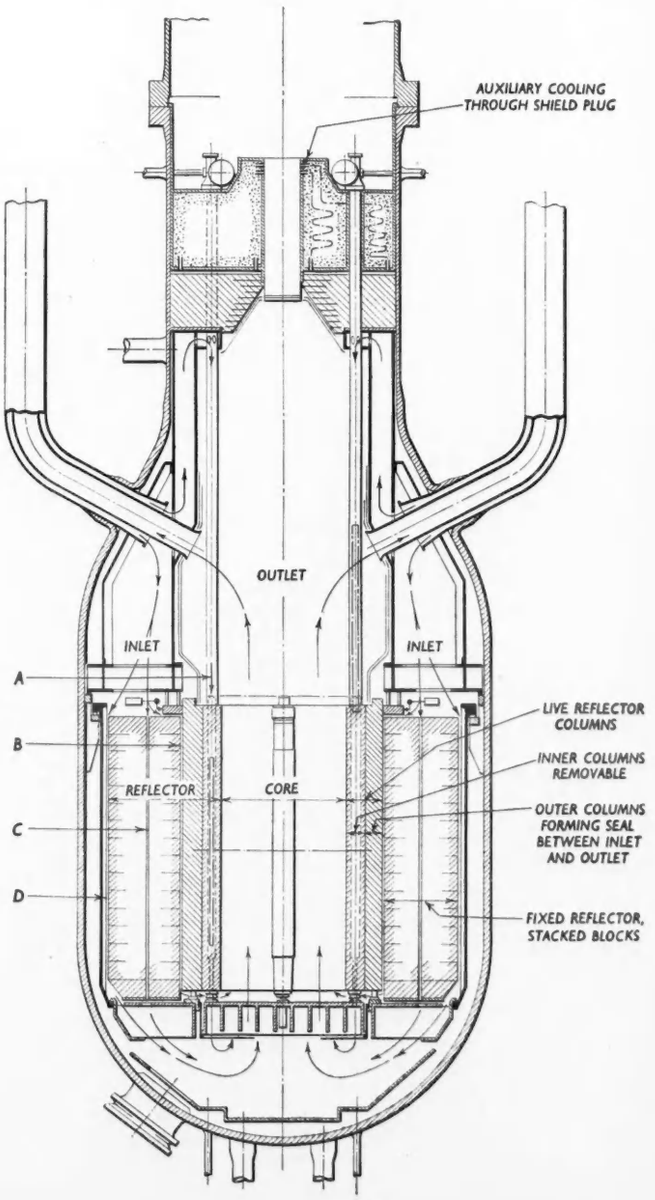

Fig. 4—Sectional diagram of reactor showing coolant flow distribution

the site. No hot cell examination is intended in this building. The building will contain industrial change rooms and an active chemistry laboratory for work such as the analysis of gas samples taken from the reactor.

The pressure vessel, with associated ducts and heat exchanger shells, will be constructed to Class 1 standard of either B.S.S.1500 or the A.S.M.E. Code of Practice. The working pressure is 294 lb square inch absolute and the maximum temperature of the vessel will not exceed 400 deg. Cent. At this temperature the creep rate will not exceed 0·2 per cent in 100,000 hours. The vessel will be stress relieved at the manufacturer's works, and the only welding carried out on site will be at branch connections, and possibly at the seal welding of the flanges. The material used will have a good notch ductility and an Izod of 35ft lb is specified at −10 deg. Cent. The vessel is expected to operate at temperatures between 300 deg. and 350 deg. Cent. Radiation damage is not expected to be serious in view of the high temperature.

Pressure control is provided by twin relief valves in parallel—one side to lift at 325 lb square inch absolute and the other at 350 lb square inch absolute—which are fitted in the dump line of the pressure vessel. The most severe rise in pressure that can be foreseen would follow a major rupture in the heat exchanger, whereby the water in that secondary circuit would enter the reactor where it could be converted to water gas. The dump tanks, the sizing of the relief valves and the dump lines have been designed to handle 500 lb water admitted to the reactor through the 2in diameter orifice under a 10ft head of water. The leak rate on the primary circuit has been specified to be not greater than 0·1 per cent per day under normal operating conditions.

Shielding

The primary circuit is surrounded by a thermal shield which consists of layers of steel and water. The water is circulated through heat exchangers, which remove most of the heat emanating from the surface of the primary circuit. Outside the thermal shield a mass concrete biological shield will reduce the radiation levels to less than 1 m.p.l. in the outer containment when the reactor is at full power. Below the reactor is a graphite thermal column for flux measurement which is carried on a steel and water thermal shield supported by concrete. The shielding below the reactor will be such that personnel will be able to enter the space beneath it when the reactor is shut down. In normal operation the maximum temperature of the concrete shield will not exceed 50 deg. Cent.

The fission product removal plant, fuel store and dump tanks will be enclosed in shielded concrete rooms, cooled, if necessary, to limit the temperature of the concrete to 50 deg. Cent. The inner containment building is surrounded by a concrete shield fitted with viewing windows. Thus this containment becomes in effect a " hot cell " facility in which major maintenance operations as well as fuel changing can be carried out by remote control techniques. The outer containment building is of concrete construction and the shielding provided by this, together with the shielding surrounding the inner containment, is sufficient to protect the neighbourhood from the radiations that would arise from a major release of fission products. The design calculations were made on the assumption that 100 per cent of the halogens and noble gases, together with 25 per cent of all other fission products, are released into the inner containment.

(To be continued)

High Energy Plasmas in Electrical Engineering*

POSSIBLE APPLICATION IN H.V.D.C. CIRCUIT BREAKING

By J. J. MATTHEWS†

Knowledge of plasma physics has been enriched in the past ten years by world-wide research efforts to achieve controlled thermonuclear reactions. The author holds a Research Fellowship, the object of which is to exploit the control of high energy plasmas in electrical engineering applications. This paper deals only with a particular example, a d.c. generator with an arc discharge in place of its armature, which has theoretical possibilities as a high-voltage d.c. circuit breaker.

LET us first consider the demand for a h.v.d.c. circuit breaker, and the problems associated with it. Direct current electric power transmission has an advantage over a.c. where long distance overhead lines or cables under the sea are concerned, due to the absence of line-charging current kVA and losses. An asynchronous system is essential for a connection between two separate a.c. systems, e.g. the proposed cross-Channel link. Experimental d.c. lines now in operation in Russia and Sweden rely for their protection upon switchgear in the a.c. circuits of the a.c./d.c. converter stations. More ambitious schemes will depend upon the development of suitable d.c. switchgear.

In these d.c. transmission circuits, a high value of line inductance is introduced to smooth out converter ripple, and to limit the rate of rise of fault currents. It is generally agreed that conventional circuit breaker designs cannot be relied upon to suppress h.v.d.c. The necessary current suppression would in any case give rise to current chopping, which cannot be tolerated in an inductive circuit.

A known solution to this problem is to connect a capacitor in shunt with the circuit breaker, to control the restriking voltage after the current has been chopped. With a little ingenuity, this capacitor can also be used to force a current reversal in the circuit breaker itself so that it can open at current zero, following normal a.c. practice.

A direct current may also be reversed by a d.c. machine. A suitable circuit is shown in Fig. 1. If the machine is provided with a

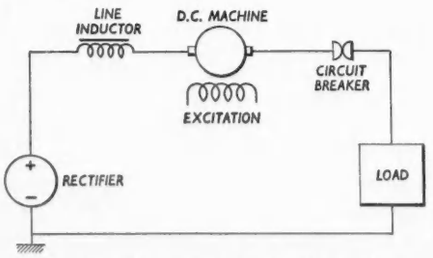

Fig. 1—D.C. machine as circuit breaker

mechanical drive or a suitably programmed excitation, the duties of the circuit breaker can be reduced virtually to those of an isolator. In the simplest case, the machine would be provided with a fixed excitation and its own flywheel inertia as load. Under these conditions it behaves essentially as a Kapp vibrator (i.e. as a capacitor) and gives rise to sustained sinusoidal current oscillations. An a.c. circuit breaker can therefore clear the circuit at the first current zero.

It is naturally not possible to make conventional d.c. machine for this high-voltage duty. At the 1958 " Atoms for Peace " conference at Geneva, however, a device was described by W. R. Baker of Berkeley, California, in which plasma is caused to rotate in a magnetic field as the armature of a homopolar d.c. machine. Such a device behaves as a Kapp vibrator, for a period of time which is limited mainly by the arc stability. In Baker's original machine, this time was only 100 microseconds, but more recent work with rotating plasmas has achieved stability for up to 1 millisecond, which is already sufficient for the device to be of interest as a circuit breaker.

" Homopolar I "

Fig. 2 shows a diagram of Baker's first rotating plasma machine, " Homopolar I."

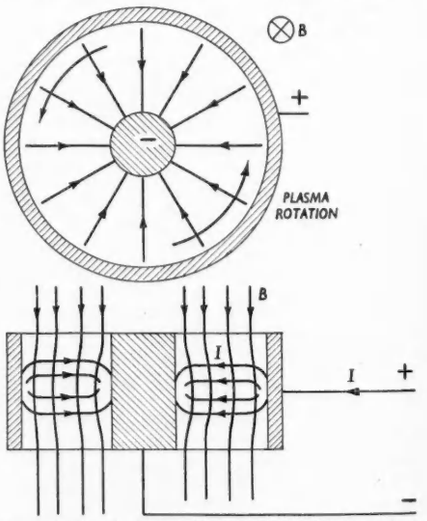

Fig. 2—W.R. Baker's "Homopolar I" (Geneva, 1958)

It resembles a Faraday disc in which the disc has been replaced by a plasma sheet between concentric electrodes. The plasma is a part of the arc formed when the circuit breaks down a low-pressure gas between the electrodes. The current flow traverses the axial magnetic field and sets the plasma into rotation. The effectiveness of a rotating plasma as a Kapp vibrator depends upon the amount of kinetic energy stored in it. In " Homopolar I," kinetic energy densities of up to 4 joules per cubic centimetre were observed. This compares with about 20 joules per cubic centimetre stored in a C.I. flywheel and $^1/_{20}$ joule per cubic centimetre stored electrically in a paper dielectric capacitor. Voltage gradients of the order of 1kV per centimetre were generated in the plasma armature, so that rotating plasmas should be very suitable for high-voltage applications. The critical feature is the short energy-storage lifetime.

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There are several energy loss mechanisms, and to devise methods of controlling them we must first study the plasma motion in more detail. For this purpose, plasma may either be considered as a conducting fluid, or as a set of charged particles whose orbits are modified by collisions.

Magnetohydrodynamic Approach

Let us first consider the plasma as a compressible, electrically conducting fluid which has been set into rotation by $I \times B$ motor forces. It would be compressed against the outer electrode by the resulting centrifugal force, if it were not for an induction drag as the conducting plasma fiuid moves in the magnetic field. To evaluate this effect, let us consider the equilibrium of a thin cylinder of plasma of radius r, thickness dr, and unit height, concentric with the electrodes (Fig. 3).

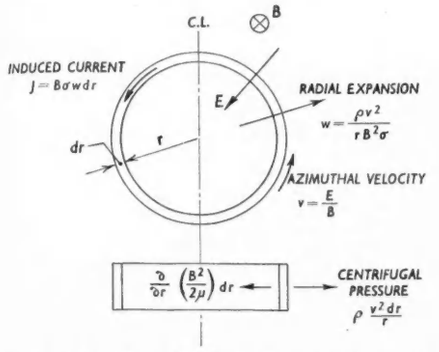


Fig. 3—Equilibrium of fluid ring in an axial magnetic field

Under equilibrium conditions, the radial current will have fallen to negligible proportions. There is therefore no radial electric field relative to the moving plasma. Transforming to fixed axes, the measured radial field E is $v \times B$. Conversely, the velocity required to generate a field E is E/B, the ratio of electric to magnetic fields. For high-voltage applications, high radial fields are desirable, in turn implying high rotational velocities. To obtain the previously mentioned electric field of 1kV per centimetre with a magnetic field of 10 kilogauss, v is required to be 10^7 centimetres per second. Such a high velocity can only be achieved in a low-density plasma fluid.

The radial expansion velocity w causes the generation of an electromotive force round the ring. A circulating current J therefore flows, equal to $B\sigma w dr$ where σ is the electrical conductivity. The induction drag just balances the centrifugal pressure $(\rho v^2/r)\, dr$ where ρ is the mass density. Equating the power dissipated by the eddy current J in the ring to the work done by the centrifugal pressure in expanding it gives the expansion velocity :

$$w = \rho v^2 / rB^2 \sigma$$

Clearly this can be reduced indefinitely by choosing a plasma of sufficiently high electrical conductivity. It has been shown that plasma conductivity is a function only of temperature T and the degree of ionisation Z :

$$\sigma \propto T^{3/2}/Z$$

so that high conductivity in turn implies high temperatures.

A high value of magnetic field is also desirable to reduce the expansion rate. The inverse proportionality of w with radius indicates that the expansion is less important with larger machines. The real significance of this is made clear by defining a time τ_w as the ratio of some characteristic length of the machine to the expansion velocity. If we put this characteristic length $= r$

$$\tau_w = B^2 r^2 \sigma / \rho v^2$$

τ_w is a characteristic time of the containment of plasma away from the machine walls, and it represents one upper limit to the possible energy-storage lifetime. Because $\tau_w \propto r^2$ large devices have inherently longer storage times.

The eddy current J, causes field-weakening inside the plasma ring. A theoretical limit to the stored energy density is that value which causes complete cancellation of the magnetic field at the central electrode. The radial magnetic field gradient can be calculated from the Maxwell equation : curl $H =$ current density, neglecting displacement currents as usual in a conductor.

The result is most conveniently expressed as

$$\frac{\partial}{\partial r}\left(\frac{B^2}{2\mu}\right) = \rho \frac{v^2}{r}$$

i.e. the centrifugal pressure is balanced by a change of magnetic field energy density across the ring. It is therefore useful to think of the magnetic field in terms of its Maxwell stresses : a transverse pressure $B^2/2\mu$ together with an equal tension along lines of force. Their effect can be seen by referring back to the diagram of "Homopolar I." In the region of radial current flow, the magnetic lines of force are stretched outwards by the centrifugal pressure from the plasma. The curvature of the field can have an important effect in delaying plasma axial motion and therefore in minimising the loss to the insulators.

Particle Orbit Model

The normal motion of a charged particle in a magnetic field is helical—a combination of a circular or cyclotron orbit perpendicular to the field, and a uniform motion parallel to it. If the time taken by a particle to complete an orbit is small compared with the average time between particle collisions in a volume of plasma, a consideration of individual particle motions will give a guide to the overall volume behaviour. This condition is fulfilled by low plasma densities and high plasma temperatures in strong magnetic fields. The upper diagrams in Fig. 4 show the

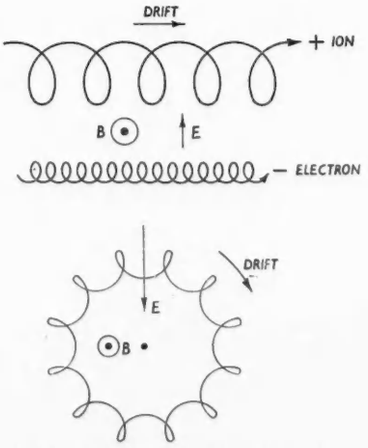


Fig. 4—Movement of ions and electrons in crossed magnetic and electric fields

motions of ions and electrons with an electric field superimposed at right angles to the magnetic field. For simplicity, motions parallel to the magnetic field have not been considered. With a magnetic field outwards, the normal ion cyclotron motion is clockwise. the electric field shown causes acceleration of the particle as it moves upwards, and deceleration downwards. The resulting cyclic changes in radius of curvature give rise to an overall drift of the ion orbit to the right. For the electron, the cyclotron motion and the forces due to the electric field are both reversed, giving rise to a drift again to the right. The drift velocity works out to be E/B independent of the nature of the particle considered. In the present application, energy storage is of prime importance : energy is stored by individual ions in proportion to their masses. Electrons, being three or four orders of magnitude lighter, store negligible energy. If the electric field is replaced by a gravitational field, similar drifts arise, but because gravitational forces are independent of charge, the electron drift velocity is now reversed in direction.

In the rotating plasma machine there is an axial magnetic field, and radially, both electric and centrifugal gravitational fields acting together. The resulting ion orbit is shown in the lower diagram of Fig. 4. The electric field causes both ion and electron orbits to drift azimuthally in the same direction. The superimposed gravitational forces cause a small increment in the ion orbit drift velocity, and have negligible effect in the electrons because of their small mass. The difference between the drift velocities of the ions and the electrons causes a circulating current to flow, which corresponds exactly with the currents calculated for the fluid case. The neglect of particle collisions corresponds to the assumption of a superconducting fluid. A calculation of the field-weakening effect has been made by Longmire and this gives the same field pattern as deduced for the fluid model.

It remains to show how the axial motion of plasma is constrained by the curvature of field lines. Consider the motion of an ion in the magnetic field configuration shown in Fig. 5. In the uniform field region, it orbits

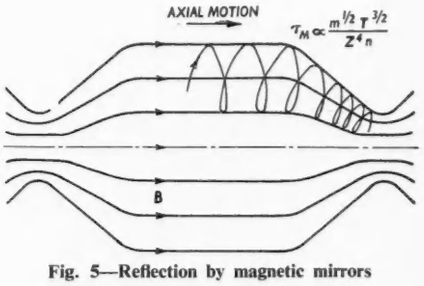


Fig. 5—Reflection by magnetic mirrors

round one particular field line while travelling with constant axial velocity. As it enters a region of increased field, by the conservation of angular momentum and energy its orbital energy increases at the expense of its axial velocity. If its ratio of axial to azimuthal velocity is high it will pass the region of maximum field and be lost. But for a low ratio, the particle will be stopped and reflected back. The particle is then said to be confined in a magnetic bottle between magnetic mirrors. The effect of superimposed plasma rotation is to increase the proportion of particles which are confined, because now, as the particle moves towards the axis in the mirror field, its axial energy must also supply the work done against the radial centrifugal forces.

In general, particles will continually be lost through the mirrors because collisions inside the bottle will tend to maintain particle velocities in a Maxwellian distribution. At low densities, particles able to escape from the bottle will normally do so without further collisions.

Energy Loss Processes

The energy loss processes may now be analysed in more detail. It is convenient to refer to a loss process by its time constant τ of energy decay. The most significant time constant is obviously the shortest one.

The losses may normally be analysed by the fluid model from a knowledge of the bulk viscous and thermal properties of the plasma. At particle densities lower than about 10^{13} per cubic centimetre when the gas kinetic mean free path becomes equal to a characteristic machine dimension, normal thermal and velocity gradients are not set up. The energy loss may then be identified with the particle flux to the walls.

The chief energy losses are :—

(1) by friction against the outer electrode (radial particle losses).

(2) by friction against the end insulators (axial particle losses).

(3) by charge-exchange.

(4) by electromagnetic radiation.

A time constant has already been derived for radial losses as an example using the fluid model. It is not usually the significant loss, but it does illustrate the general trend of energy lifetimes :

$$\tau \propto T^{\frac{1}{2}}/n$$

where n is the particle density.

In the fluid model, the end loss may be identified with windage friction at the end insulators. It may be measured electrically as the conventional no-load loss of the machine. In " Homopolar I," the end loss is the

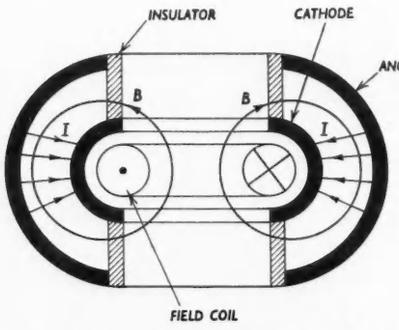


Fig. 6—W. R. Baker's "Homopolar III" (Uppsala, 1959)

significant loss. Baker has cunningly eliminated it in a new version, " Homopolar III " (Fig. 6), in which the electrodes are bent to bring the insulators parallel to the axis. As the plasma accelerates, it is dragged away from the insulators by centrifugal forces. Preliminary results show that end friction is no longer significant.

In general, energy storage lifetimes are inversely proportional to plasma density. In " Ixion," the rotating plasma device for which the longest lifetimes have so far been reported, plasma densities are two orders of magnitude less than in " Homopolar." Magnetic mirrors are used to isolate the ends of the " Ixion " plasma from the insulators, but even so, the loss rate through the mirrors is still the significant loss. The associated time constant is the time for the particle confined between the mirrors to achieve a Maxwellian velocity distribution.

$$\tau_m \propto \frac{m^{\frac{1}{2}} T^{3/2}}{Z^4 n}$$

Note the usual dependence on $T^{3/2}/n$. The $(\text{mass})^{\frac{1}{2}}$ term implies that electron losses will be more rapid than ion losses, but this results in a space charge electric field across the magnetic mirrors which inhibits further electron losses without promoting a corresponding increase in ion losses.

The inverse fourth power dependency on the degree of ionisation of the ions Z is rather serious, because most materials are readily raised to multiply-ionised states at high temperatures. Therefore only hydrogen (which is not multiply-ionised) and perhaps sodium and lithium (which have high second ionisation potentials) can be contained significantly by magnetic mirrors. Impurities from the insulators and electrodes therefore carry away a disproportionately large energy flux. Since this gives rise to wall erosion, the process may be cumulative. Suitable refractories must be chosen for both electrodes and insulators and care must be taken to maintain the purity of the gas filling.

" Charge-exchange " occurs between plasma ions and neutral gas atoms. In a highly ionised plasma, there is a high probability of an ion being neutralised by collecting an electron from a neutral particle. The neutralised ion retains its original kinetic energy, and travels out of the discharge unaffected by magnetic containment, leaving a slow ion in its place. The neutral particle density must therefore be kept low, further emphasising vacuum cleanliness.

Electromagnetic radiation consists of Bremsstrahlung or " white " noise resulting from coulomb encounters, and line radiation from the spontaneous de-excitation of atomic states. Bremsstrahlung radiation cannot be prevented, but its intensity is fortunately low. Line radiation represents a serious loss at high temperatures, but it may be avoided altogether by using hydrogen which is not excited above its ionised state.

Instabilities

The lifetime of the rotating plasma is further limited by instabilities which occur in the equilibrium between plasma and magnetic fields. The most important instability probably is the " interchange instability," a process whereby a kink in a magnetic field line grows cumulatively by electromagnetic coupling with plasma inertia forces. If this happens in the rotating plasma, the concentric circles of plasma motion are distorted, and the mechanisms for radial containment by circular eddy currents is destroyed. Finally, the plasma condenses into arc filaments like the spokes of a wheel. This process has been analysed by Rosenbluth and Longmire who have predicted a growth rate for it proportional to $\sqrt{g\lambda}$ where g is the centrifugal force and λ is the wavelength of the kink in the plasma.

For an elliptical instability, $\lambda \propto r$ and since :

$$\sqrt{gr} = v = E/B$$

the growth rate is proportional to the electric field in the machine for a given magnetic field. A further time-constant may be defined

$$\tau_i \propto \frac{r}{v} \propto \frac{rB}{E}$$

after which the plasma will be expected to have broken up by instabilities.

The process of design of rotating plasma machines consists in optimising each of the values of τ described above.

Experimental Programme

A small " Homopolar " device is at present under construction to test whether or not it can be used successfully to break an elementary d.c. circuit. If this shows promise, the work will be expanded to determine the constants of proportionality for the various loss time constants, and to verify the scaling laws.

Lea Hall Colliery

With the opening of Lea Hall Colliery, near Rugeley, a new lease of life has been given to the coal-mining industry at Cannock Chase. For this mine two new 1300*ft deep shafts have been sunk and when it is fully extended some* 23 *miles of underground roadways will give access to eleven seams, with certain reserves of almost* 148 *million tons of coal. It is planned to produce up to* 1,500,000 *tons of coal a year and, using extensive mechanisation, give an output of* 43½ *cwt per manshift. When the workings are fully extended this new mine will have cost about* £14,000,000.

THE new Lea Hall Colliery which was opened in the West Midlands Division on July 19 last, is the first project of its kind to be conceived, planned and carried out by the National Coal Board. It will develop a virgin area of coal containing all the best Cannock Chase seams and its output will replace tonnage lost by the exhaustion of collieries in the older part of the Cannock field. This project was the outcome of a decision of the N.C.B. to explore reserves in an area east of a big geological disturbance, known as the Eastern Boundary Fault, where previous attempts to prove coal had been abandoned. An appraisal bore-hole revealed the presence of Cannock Chase seams at a depth between 700ft and 2000ft below the surface. A subsequent series of bore-holes showed that over an area of 4200 acres there were certain reserves of coal in eleven seams with an average total thickness of 51ft and totalling some 148 million tons. With this knowledge it was considered that, with the establishment of a new colliery and the rebuilding of those in the older part of the coalfield, a new lease of life could be given to mining in Cannock Chase.

The new colliery is sited on the plain of the River Trent about a mile east of Rugeley, and when the workings are fully extended it will have cost about £14,000,000. Of this total, shaft sinking and equipment will account for £1,335,000 ; main tunnelling underground £4,630,000 ; underground plant £2,950,000 ; coal preparation plant £1,250,000 ; and other surface plant and structures £2,546,000. It is planned to produce up to 1,500,000 tons of coal a year with an output of 43½ cwt per manshift when the mine is fully completed.

When the possibility of the new colliery was being examined the Central Electricity Authority (now the Central Electricity Generating Authority) was contemplating the construction of a power station in the same area. These two projects have been carried out in conjunction, and the new 600MW power station at Rugeley closely adjoins the colliery as can be seen in one of our illustrations. About half the output of the colliery will go to the generating station

Lea Hall Colliery with Rugeley power station on the left

which will take all the small coal and to this there will be added crushed coal from the industrial type seams. For the underground workings laid out on the "horizon" principle, the main horizon roadway networks are at depths of 880ft and 1200ft, the lower being used for transport of coal and ventilation, and the upper network for ventilation, transport of men and the stone refuse returned from the surface for underground stowage. When they are fully extended over the area to be worked there will be some 23 miles of roadways, most of them being 14ft wide by 12ft high, and those near the pit bottom 21ft wide by 15ft high.

The site selected for the colliery was not easy to develop as the water table is only 6ft below the surface and alluvium is present to a depth of up to 70ft. These conditions not only entailed extensive piling for the foundations of plant and buildings, but considerable difficulties in shaft sinking, because below the alluvium there is 640ft of water-bearing sandstone and pebble beds. The shafts were sunk using established freezing techniques; they have a finished inside diameter of 24ft—which called for an excavation of 29½ft diameter—and reach a depth of 1300ft, from which level output can be maintained for about sixty years without need for further deepening. This shaft sinking was carried out by N.C.B. labour, and in the construction of the two shafts some 48,578 tons of concrete were used.

Coal from the working face is loaded on to belt conveyors delivering to stations where it is loaded into 3-ton capacity mine cars. If, however, the coal is delivered along a road between two main horizons it is shot into a spiral chute extending down a staple shaft, at the bottom of which it falls into the mine cars. The trains of mine cars and cars for stone and materials are hauled along the underground roadways by 65 b.h.p. battery locomotives on 2ft 6in gauge tracks. At the shaft bottom mechanical means have been installed for marshalling and controlling the mine cars and introducing them in pairs into the cages. At the surface the cars are handled by compressed air equipment and emptied in tipplers, each of which is designed to take two classes of coal or dirt by the use of a time-controlled chute mechanism.

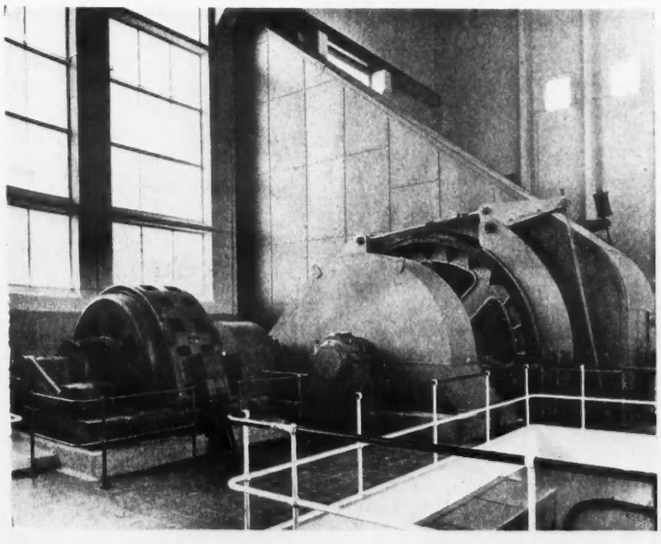
At No. 1 shaft one of the two cage winding engines has been installed, and when both are in service they will be capable of winding coal at the rate of 600 tons an hour. The single engine at No. 2 shaft used for men and materials is fitted with one pair of cages. The pulleys over which the winding ropes of these engines pass are mounted on 134ft high "A"-shaped headgears of all-steel construction. These winding engines, together with the coal and dirt handling plant, were supplied by the General Electric Company, Ltd.

The winder installed at No. 1 shaft is a double-drum 3·3kV machine rated at 2100 h.p., and that at No. 2 shaft, to be seen in one of our illustrations, a single drum 2100 h.p. machine. The second winding engine now being installed at No. 1 shaft will be of 1500 h.p. and will be in operation by the middle of next year. Each of these winding engines is of conventional G.E.C. design with the closed-loop speed control system which ensures an adequately close relationship between the steady rope speed and the position of the driver's lever.

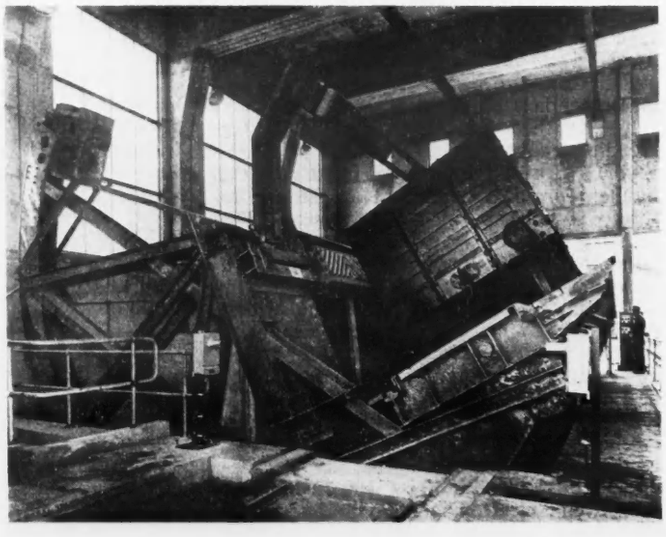
Coal Handling Plants

Four handling systems installed at the colliery by G.E.C. are so interlinked with each other that a variety of requirements are provided for. One system transports best coal from the two shafts to a washery plant at present under construction. Another system using the same tipplers and apron feeders located in the shaft-houses transports industrial coal from the mine to the crushing and blending plant. The third system involves the provision of a wagon tippler and conveyors to transport imported industrial coal to a separate crushing plant and thence to the blending bunkers with provisions to use this system to pass best coal to the washery or imported dirt to the dirt crushing plant. Finally, a fourth system deals with the transport of the R.O.M. dirt to a crusher house and disposal bunker. The designed throughputs of these systems are 600 tons per hour, 600 tons per hour, 300 tons per hour coal or 500 tons per hour dirt ; and 600 tons per hour respectively.

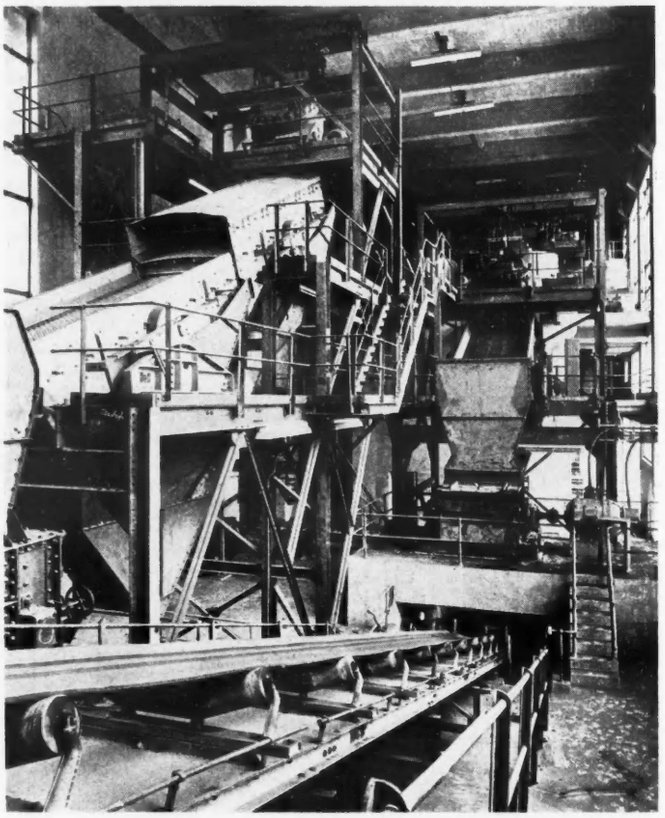
The upcast shaft-house plant consists of a tippler, designed to tip one 3-ton coal capacity mine car every thirty seconds, feeding to a 48in wide apron feeder for coal or a similar feeder for dirt. These feeds in turn deliver to 48in wide troughed conveyors. The discharge to either of the apron feeders is controlled by a flopper chute located under the tippler. Similar equipment installed



2100 h.p., single-drum, a.c. winder for downcast shaft of Lea Hall Colliery



Side-discharge tippler for handling imported coal or dirt at Lea Hall Colliery



The industrial and imported coal systems run side-by-side at this point just before the coal goes to the blending bunker

at the downcast shaft is arranged for duplication at some future date.

Best coal raised at the upcast shaft is discharged to a 48in wide coal conveyor and is passed to a conveyor which also takes the best coal output from the downcast shaft feeders. This coal is then transported by a 600 tons per hour 48in wide troughed conveyor to the washery plant at present under erection.

The coal being delivered to the industrial coal system is selected at the tipplers, and in the case of that raised at the upcast shaft is transported by the same 48in wide conveyor as far as the bifurcation chute at the downcast shaft-house where it is passed to the industrial-coal conveyor. This conveyor, also of 600 tons per hour capacity, delivers the coal to a single-deck "Gyrex" scalping screen which extracts the —6in coal, the +6in passing over a 60in wide picking belt for removal of dirt and thence through a Pegson gyratory crusher. The —6in coal then passes over two "Gyrex" screens arranged in tandem to screen out the —1½in, and the oversize passes through a hammermill secondary crusher.

The crushed coal is transported to the blending bunkers by a 42in wide belt conveyor, and a radial conveyor fitted over the bunkers provides facilities for feeding to three 150-ton capacity compartments. The crushing system is capable of dealing with large coal of 24in cube and coals having a wide range of hardness.

The import-coal system has the widest flexibility of application. It can deal with 300 tons per hour of imported coal for crushing, or it can transport an equal amount of best coal to the washery, or it can pass 500 tons per hour of imported dirt to the dirt crushing system. Imported rail-borne coal is discharged into a bunker by a side-discharge tippler and is delivered by a "Sherwen" electromagnetic vibrating feeder on to a 36in wide conveyor. This conveyor delivers to a 300 ton per hour capacity screen and through a separate crushing system, is processed in similar manner to that described above for the industrial coal system. Since the capacity of this system is only half of that of the industrial coal system, the capacities of the screens and secondary crusher are also somewhat smaller. Part of the equipment for handling industrial and imported coal can be seen in one of our illustrations.

The coal-blending plant consists of six 150-ton capacity bunkers fed by radial conveyors which permit wide flexibility of use. The normal allocation is three bunkers to the Lea Hall product, one to imported and two to the <½in best coal which is screened out at the washery and transported to the blending bunkers.

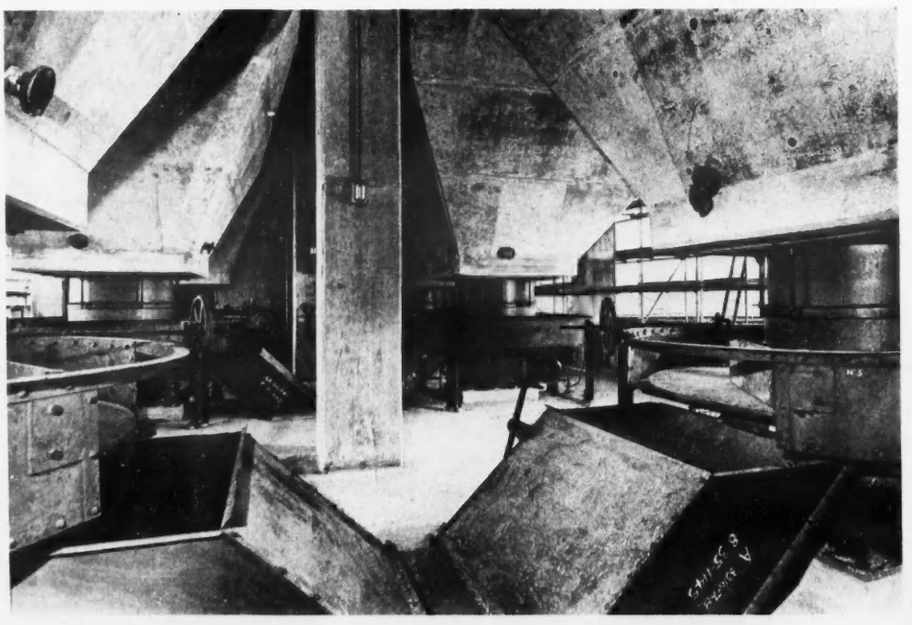
Blending will be effected by the 9ft diameter feed tables located at the discharges of the bunkers shown in the illustration. These tables will feed a 36in wide conveyor with a 100 per cent standby to the reception hopper of the Rugeley Power Station of the C.E.G.B. The two belts are fitted with weighers and samplers with a sampling house located immediately adjacent to the reception hopper.

Dirt-Handling System.—When dirt is sent up either shaft, it is discharged by a rotary car-tippler on to a 48in wide apron feeder and from there on to a 48in conveyor linking the two shafts. It is then passed through a two-roll grizzley screen set at <6in. The undersize material is conveyed to a crushed-dirt bunker, but the oversize is led via a 60in picking belt to a jaw crusher which reduces the product to <6in before it enters the crushed-dirt bunker.

At present the dirt is removed from this bunker for direct disposal, but an extension to this plant, when operating, will further crush the stone and deliver it back to the shaft head for stowage underground. A feeder with a capacity of 350 tons per hour to be supplied under this contract will remove the dirt from the crushed-dirt bunker and a 30in belt will convey it to a screen with a 2½in mesh. The oversize from this screen will be reduced to <2½in in a cone crusher. The fines from the screen and the crusher product will then be screened to <½in, the undersize being deposited by a bucket elevator into a fines dirt bunker. The oversize, however (i.e. 2½in to ½in), from both screens will feed on to a common conveyor taking it back to a 400-ton storage bunker located at the head of the upcast shaft. Two feeders will be installed to remove this dirt from the bunker for loading into mine cars, ready for transporting down the mine.

In addition to the dirt-handling plant being fed from the shafts, it can also be supplied with dirt from the import system as already stated.

For mine ventilation purposes two radial flow fans, one acting as a standby, have been installed by Aerex, Ltd. These fans have a variable capacity from 150,000 to 535,000 cubic feet per minute and at the full rating it is stated that nearly 6 tons of air will be circulated for every ton of coal extracted.



Six rotary feed tables for removing the coal from the blending bunkers

To provide compressed air for mining, tunnelling, stowing and other underground requirements two electrically-driven air compressors have been supplied by Daniel Adamson and Co., Ltd. The larger of these machines is designed to deal with 6000 cubic feet per minute of air, and to discharge at 80 lb per square inch gauge when supplied with cooling water not exceeding 80 deg. Fah. in temperature. This machine runs at 9768 r.p.m. and is driven by a B.T.H. synchronous motor which has a continuous maximum rating of 1313 b.h.p. at 1500 r.p.m. The speed increasing gear is flexibly coupled to both the motor and the compressor, and the main lubricating oil pump for the unit is driven off the low speed shaft of the gearbox. At designed full load the power required at the compressor coupling is 1147 b.h.p., the margin between this and the continuous maximum rating of the motor being necessary to account for changes in the ambient and operating conditions for the machine.

The smaller compressor is generally similar but is designed to deliver 4000 cubic feet per minute of air under the same operating conditions and is driven by a motor continuously rated at 895 b.h.p. The compressor speed is 10,922 r.p.m. and the power required at the motor coupling with the compressor operating at design conditions is 822 b.h.p. Both machines are externally cooled, each having seven stages with intercoolers after the second and fourth stages. An after-cooler is also provided which cools the delivered air to a temperature of 140 deg. Fah.

Electrical power is being supplied from the national grid and provision has been made for a demand of 15,000 kVA for use at the coal face alone in this mine. A coal-fired plant with three high-pressure hot water boilers, each 9,000,000 B.Th.U. per hour capacity, provides heating and hot water for the whole of the suface plant. Other surface installations include pit head baths and a large canteen.

The consultants for the surface works at this new mine were Sir Alexander Gibb and Partners, and the main civil engineering contractor was John Laing and Son, Ltd.

OTHER CONTRACTORS

Freezing, the Foraky Boring and Shaft Sinking Company, Ltd.; coal preparation plant, Head Wrightson Colliery Engineering, Ltd.; landsale plant, W. J. Jenkins and Co., Ltd.; heating boiler plant, Edwin Danks and Co. (Oldbury), Ltd.; winding engines, The General Electric Company, Ltd.; headgears, the Lilleshall Company, Ltd.; surface conveyors, coal and dirt crushing plants, The General Electric Company, Ltd.; airlock and cage equipment, Gutehoffnungshütte Sterkrade Aktiengesellschaft; decking and car handling equipment, the Norton-Harty Engineering Company, Ltd., Plowright Brothers, Ltd.; ventilating fans, Aerex, Ltd.; main substation electrical equipment, Associated Electrical Industries Ltd.; coal sampling plant, The General Electric Company, Ltd.; piling and foundations for temporary winding houses, Holst and Co.; embankment for railway connection, &c., Sir Alfred McAlpine and Son, Ltd.; railway connection and sidings, T. W. Ward, Ltd.; air compressors, Daniel Adamson and Co., Ltd.; staple shaft winding engines, John Tinsley, Ltd.; materials transport equipment, W. G. Allen and Son (Tipton), Ltd.; main underground pumps, E. N. Mackley and Co.; underground main switchgear, Associated Electrical Industries Ltd.; medium tension inbye switchgear, A. Reyrolle and Co., Ltd.; battery locomotives and charging equipment, The English Electric Company, Ltd.

Coldwater 600kV Experimental Line*

No. II—(*Concluded from page* 275, *August* 12)

Within the next few years, the Hydro-Electric Power Commission of Ontario plans to develop a group of hydraulic sites in a remote section of the province. Incorporation of this generation into the system will require extra-high-voltage transmission, probably in the 460*kV range. To provide design information for the e.h.v. transmission lines required, a high-voltage experimental station has been constructed. Known as the Coldwater e.h.v. Project, the installation comprises two three-phase bundled-conductor test lines, each about* 2500*ft long, operating at voltages up to* 600*kV phase-to-phase. Information from the Coldwater Project will be used to determine the radio interference and corona loss characteristics of particular bundled-conductor arrangements, and to verify analytical methods which have been devised for applying test data to a range of actual line designs.*

AS stated in last week's article, the Coldwater Project was set up to deal with certain specific problems in connection with the design of proposed extra high voltage transmission for Ontario and these are briefly stated below:

(1) Determine corona losses and radio interference levels on various sizes and arrangements of bundled conductors, over a range of extra high voltages, for the purpose of determining the most economic conductor size and arrangement which will provide satisfactory operation.

(2) Measure the extent of radio interference from certain designs of conductor and bus hardware as a guide to the future design of suitable hardware.

(3) Determine suitable clearances for various live-line maintenance techniques to establish the influence of this requirement in the design of towers.

It is hoped that the Coldwater tests will verify analytical methods which have been developed to enable the calculation of the corona losses and radio interference levels of a wide range of e.h.v. designs, using limited amounts of test data.

* Extracts from a paper presented by J. G. Cassan and N. J. McMurtrie (Hydro-Electric Power Commission of Ontario) at the Conférence Internationale des Grandes Réseaux Électriques à Haute Tension (C.I.G.R.E.), Paris, June, 1960.

COLDWATER TEST FACILITIES

The site of the project is near Coldwater, Ontario, which is not far from Waubaushene at the southern tip of Georgian Bay. The Coldwater site was chosen for two principal reasons. It is close to a 115kV transformer station, and immediately adjacent to a 44kV feeder suitable for supplying power to the three-phase, 600kV bank of test transformers. This particular site is also in an area of relatively weak radio station field strength, which permits radio noise measurements to be made without serious interference from commercial broadcasting, and which incidentally simulates the conditions in Northern Ontario.

The installation includes two separate test lines, since this permits measurements to be made simultaneously on two different conductor sizes and phase spacings, and thereby facilitates a direct comparison of results under identical conditions of weather and conductor surface ageing. In addition, the first two line arrangements being tested have been selected so that the estimated optimum conductor size, for operation at 460kV, will lie somewhere between the two values used. Thus, it is intended that the first two test arrangements should bracket the optimum conductor design for such a line and permit conclusions to be verified by interpolation of results.

Test Lines and Structures.—The two experimental transmission line sections, running approximately north and south, each consist of five spans for a length of 2500ft. They are essentially identical in construction except for conductor size. The north section is strung with a bundle of four conductors of 1·1in diameter. The south section also uses a four-conductor bundle, but each has a diameter of only 0·8in. Located at the centre point is the high-voltage power supply area from which either or both of the line sections can be energised. Each line section is supported by two terminal structures and four suspension structures at approximately equal intervals through their length. The two line terminal structures at the power supply

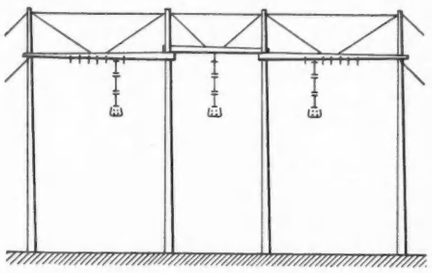


Fig. 1—Outline of Coldwater 600kV suspension structure showing the possible variation in phase spacing from 24ft to 36ft in 2ft steps

area also support the high-voltage bus beneath which the three-phase, 600kV bank of test transformers is located.

A suspension structure is shown in Fig. 1. The structural members, both upright and crossarm, consist of wood poles. The crossarms are additionally supported by steel cable hangers and the entire structure is guyed to each side. The upright poles are generally 80ft or 85ft in length. The outside phase positions on the structure are laterally adjustable in 2ft steps in order to provide for a variability in phase spacing from 24ft to 36ft. Four ground cables are used, one at the top of each pole, in order to provide sufficient shielding over the entire range of phase spacing. Wood structures were used on the test lines because of their ready availability and low cost.

The suspension hardware is illustrated in detail in Fig. 2. The four conductors are held by conventional suspension clamps. The top two clamps are suspended from a yoke plate and the bottom two clamps are suspended from straps attached to the top clamps. A grading ring of 2½in outside diameter is attached to the yoke plate and envelops the conductor hardware in the vertical plane as shown. The spacing between the conductors in the bundle is variable from 8in to 18in by means of a number of prepunched support positions in the yoke plate and the suspension straps.

The suspension insulators (Fig. 1) are Langstab anti-fog units which were found to be essentially corona free at the maximum voltages to be used and were thought to involve lower leakage currents under certain weather conditions. The suspension string consists of three Langstab insulators, each 4ft in length and equipped with grading rings at the top and bottom of each unit. During the preliminary tests, some visual corona appeared on the bottom insulator grading ring which is shown in Fig. 2. For the Coldwater tests, therefore, these bottom grading rings were polished to a very smooth surface and chromium plated. Had this phenomenon been discovered earlier, a larger ring might have

been used as an alternative at this location.

The design of the conductor hardware and grading rings, as well as the selection of insulators, for the Coldwater Project was based on a number of preliminary laboratory tests. It was intended to reduce corona and radio interference from these items to an absolute minimum in order to prevent hardware noise from creating unknown errors in the measurements of radio interference from the conductors. It may be of interest to note that

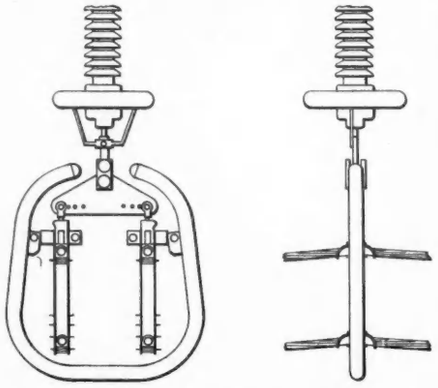


Fig. 2—Suspension hardware and grading rings. Conductor spacing can be varied to 8in, 12in, 15in or 18in

this conductor hardware has been found to be essentially free of visible corona at the maximum voltage of 600kV.

The terminal structures are also made of wood, with the exception that the crossarms consist of steel " H " beams. They provide the same variability in phase spacing, from 24ft to 36ft, as do the suspension structures. The two line terminal structures at the power supply area form the support for the high-voltage bus and disconnecting devices which are located above the power transformers. The bus is fixed in position at a phase spacing of 36ft and consists of a four-conductor bundle, with a conductor diameter of 1·34in. This relatively large conductor size was selected in line with the general design policy of eliminating any sources of corona in the power supply area. In order to minimise insulator leakage losses, the total number of insulator strings was reduced by using single strings of heavy duty Langstab insulators at the terminations. The conductor loops at the power supply terminal structures were fashioned from 3½in aluminium tubing. Radio-frequency wave traps are installed in these loops at the point where they are supported by suspension insulator strings. These wave traps serve the dual purpose of preventing any noise which may originate in the power supply area from appearing on the test lines, and providing a suitable terminating impedance for each test line.

In order to measure the leakage currents on the insulators being used at Coldwater, a short stub bus has been erected at one side of the power supply area. This bus consists of a four-conductor bundle of the same size as the high-voltage bus. The bus insulators and hardware, for both terminal and suspension assemblies, are the same as those on the test lines.

On the opposite side of the power supply area from the insulator stub bus, and at right angles to the two transmission line sections, a single-phase station-type test bus has been erected. It consists of a short section of rigid tubular bus, 3in in diameter, supported on post-type insulators, and a short section of flexible strain-type bus consisting of a two-conductor bundle with a conductor diameter of 1·75in. These bus sections can be energised by connection to one of the test transformers in the power supply area. It is intended to use the station test bus for the purpose of observing visible corona and measuring generated radio noise on various types of bus hardware and fittings as a guide in the design of these items for proposed future e.h.v. stations.

A steel structure, consisting of two slender shafts connected at the top by a crossarm girder, has been erected temporarily around the middle phase at a mid-span location on the test line. This structure, which will eventually be fitted with suspension insulators and hardware, is being used as a platform from which to carry out experiments in determining suitable clearances and techniques for live-line maintenance at extra high voltages. Steel was selected as the structural medium in this case in order to simulate the electric field conditions which a lineman will meet on a future steel tower line. Because the location of this structure, between the phases at mid-span, limits the extent to which the phase spacing can be reduced on the test line, provision has been made for this steel structure to be dismantled during those periods when it is not in use.

Power Supply.—Power is supplied from a 44kV line to the three-phase regulator. This unit is rated at 3000kVA, the approximate charging load of the two test lines when equipped with four-conductor bundles at the minimum phase spacing. It provides a regulated output voltage controllable from 5·3kV to 15·7kV phase-to-phase, giving a range of 205kV to 600kV on the e.h.v. bus. This voltage range is achieved by means of two on-load tap changers, one providing a coarse voltage control in thirty-two steps of 10kV on the e.h.v. base, the other providing a fine control in thirty-two steps of 2·5kV. A special modification of the coarse-control tap changers permits the centre phase voltage to be displaced from the other two to allow balancing of the phase currents on the unsymmetrical test lines. By this means the conductor surface voltage gradients of the three phases can be equalised, simulating the so-called " hybrid " construction in which the conductors in the middle phase position are larger than those in the outer two phases.

Each of the three single-phase high-voltage test transformers is rated 15·7kV/350kV, 1667kVA and they are connected delta-grounded-Y. The transformers are equipped with 345kV bushings, and were impulse-tested at 1300kV. With these bushings the transformers can be operated continuously at voltages up to 500kV. Operation at 500kV to 600kV is limited to two hours in eight, because of possible overheating from bushing dielectric loss. Low-voltage switching is accomplished by means of an oil circuit breaker on the 15kV side of the regulator transformer and by an air-break switch on the 44kV side. Because of the relatively low insulation level of the high-voltage transformers, which are protected only by rod gaps, the circuit breaker is equipped with resistors to minimise switching overvoltages.

Special disconnecting devices are used in the high-voltage bus so that tests can be made on either or both of the test lines. These are operated manually by means of magnesium operating rods which can be left in position to provide ground connections on the open line.

Instrumentation.—Several quasi-peak radio noise meters are used for radio interference levels at the Coldwater Project. One of these is designed to permit the use of either the American Standards Association time constants or those of the International Special Committee on Radio Interference (C.I.S.P.R.). Thus, the test data may be compared with results of other tests in Europe or America.

Two 350 kV coupling capacitors are used to permit measurement of generated noise on the two test lines. Mounted on rubber-tyred wagons, these can be positioned for measurements on any phase of either line.

Recording instruments are used for simultaneous recording of the generated and radiated radio interference at selected points on the two test lines, to enable a statistical analysis of the noise levels to be obtained.

Corona loss instrumentation is provided to measure losses on the two lines simultaneously, with an accuracy of 0·5kW per three-phase mile. Since the parameters of the two test lines differ, the two lines do not have equal losses, so that special arrangements are required to determine the loss of each line separately. This is accomplished by making two measurements, one of the total loss of two lines, and one of the difference loss. From these, the loss of each line is obtained.

Total loss is measured by instruments located at the ground end of each high-voltage transformer winding. Instantaneous corona loss readings are obtained from special wattmeters with a full-scale power factor of 1·25 per cent. Modified watthour meters are used as the primary elements for recorded loss measurements. The transformers are mounted on low-voltage insulators to isolate the tanks from ground. The ground end of each high-voltage winding is connected to the transformer tank so that, by interposing the current coils of the loss-measuring instruments between tank and ground, the transformer load current flows in the metering circuit. The transformers are equipped with internal shields to keep the charging current of the windings out of the loss circuits. Voltage for the loss-measuring instruments is obtained from a metering winding at the ground end of each high-voltage transformer winding. To avoid measurement errors caused by power transfer between the outer phases of the lines, the wattmeter neutral voltage is shifted away from the test transformer neutral so as to produce readings close to zero when the lines are lossless.

The difference loss between the two lines is measured by similar instrumentation at ground level. Metering current for the difference loss instruments is obtained from a differential current transformer at the top of each high-voltage transformer bushing, and is transmitted by a frequency-modulated v.h.f. radio transmitter to the instruments, via a receiver located at ground level. The differential current transformer, transmitter, and associated power supplies are contained in a metal housing mounted on the top of each high-voltage bushing. Power is obtained from a 2·3kV winding at the high-voltage end of the 350kV winding.

To permit the periodic measurement of insulator loss, a short stub bus carrying several strings of insulators is energised from one phase of the high-voltage bus. A time switch, at selected intervals, transfers the input of the frequency-modulated transmitter for this phase from the differential current transformer to a current shunt in the stub bus. The insulator losses are thus measured by one of the ground-level wattmeters. Since the entire current input to the insulator loss bus is metered, this method avoids the error inherent in methods wherein only a part of the insulator loss current is obtained from a tapped connection to the last unit in the string.

Meteorological instruments are provided

to measure rates of rainfall and snowfall, temperature, barometric pressure and relative humidity, and to detect the onset of rain when very light rainfall occurs.

While much of the test data will be obtained from indicating instruments during test runs, recording instruments are used to simplify data collection and to record information during periods of unattended operation. For this purpose output signals from the corona loss and meteorological instruments are fed to suitable transducers and pulse counters and thence to a self-balancing multi-point recording potentiometer. The recorder prints each quantity at preselected intervals of five minutes or fifteen minutes.

Test Programme

The test installation at Coldwater was first placed on potential, single-phase, in June, 1959, and upon completion of the major construction work was placed in three-phase operation in early August.

The initial period of operation has been devoted primarily to continuous operation at 500kV to age the conductors. It is expected that periodic radio interference and corona loss measurements will serve to indicate when conductor ageing is complete, whereupon the final test programme will be carried out.

Radio noise measurements will include frequency spectra at various locations along the line, longitudinal and lateral interference level profiles, and recorded measurements of both radiated and generated interference. Measurements along the lines will be made in a frequency range from 200 kc/s to 20 Mc/s, although most recorded data will be obtained at the exact mid point of each test line at a frequency of 1 Mc/s. Sufficient information will be obtained to permit full evaluation of the methods discussed earlier for interpreting short-line interference data, so that the results can be applied to a range of long-line designs.

Much of the corona loss testing will involve variable voltage runs in various weather conditions to establish more accurate values of the weather-conductor constants in the corona loss equation. This is considered to be a more useful approach than the accumulation of long-term corona loss records, since it is felt that more can be accomplished in the time available, and that a method of calculation will thus be provided for dealing with various types of line. The recorded data will, of course, be useful in checking the accuracy of total energy loss determinations. Voltage runs will be made with descending voltage, allowing stabilising periods at the initial voltage and at subsequent lower voltages. During preliminary variable voltage tests in rain, stable losses were obtained at the highest voltage in about ten minutes and at subsequent lower voltages in about two minutes. Thus a voltage run can be completed in about one hour.

Variations in the conductor arrangements will be made in accordance with results obtained as the radio interference and corona loss tests progress. Initial test conditions include a bundle spacing of 15in and phase spacings of 26ft for the 1·1in conductor and 32ft for the 0·8in conductor. In the later stages of testing one of the 1·1in conductors probably will be removed from each phase to permit evaluation of a three-conductor bundle, with the original 0·8in conductor bundle unchanged, for comparison. At least one change of bundle and phase spacings will be made.

Work on the single-phase station test bus will consist primarily of tests for visible corona and generated noise on conductors and hardware. On the basis of these tests, conductor arrangements and hardware designs will be selected to provide suitably low noise levels in the vicinity of stations in the proposed e.h.v. system. It is expected that the single-phase data from these tests can be extrapolated to three-phase conditions by conversion factors determined by comparative data from special single-phase and three-phase tests on the three-phase test lines. Provision has been made for converting the station test bus to a three-phase arrangement if this should prove to be impracticable.

The special tower for live-line maintenance testing will be used for simulated maintenance operations. Measurements will be made to determine electric field strength at work locations, and the electrostatic charges and shock currents to which linesmen are subjected under various working conditions. These data will be co-ordinated with laboratory tests to determine the requirements imposed on climbing clearances, tool design and working techniques.

Supercritical Generating Units for Drakelow-C Power Station

The Central Electricity Generating Board has announced its intention to place contracts worth about £15,000,000 for two large supercritical-pressure generating units to be installed at Drakelow-C power station, near Burton-on-Trent. Since steam generation will be at pressures above the supercritical condition (3,206 lb per square inch absolute 705 deg. Fah.) at which water passes directly into superheated steam with zero latent heat of evaporation and no change in density the boiler requires no steam drum. One boiler will be built by Babcock and Wilcox, Ltd., Renfrew, and the other by International Combustion Ltd., Derby, and the turbo-alternators by Associated Electrical Industries (Manchester) Ltd., and the English Electric Company Ltd., Stafford, respectively. Each generating unit will have an output of 375MW from a single shaft machine.

Steam conditions for both turbines are 3,500 lb per square inch gauge at the turbine stop valve and 1,100 deg. Fah. The steam, after partial expansion, will pass through the boiler again, and will be reheated to 1,050 deg. Fah., before re-entering the turbine for expansion to vacuum. These steam conditions show a marked advance on the present conditions of 2,300 to 2,400 lb per square inch gauge at 1,050 deg. Fah., used for the large generating sets now being built and commissioned. Although the cost of the units is slightly higher than that of similar size sub-critical units, they will generate electricity at a lower cost which will counterbalance the extra capital charges. Each boiler will burn about 150 tons of pulverised fuel per hour originating from the East Midland coalfield.

The Babcock and Wilcox boiler, scheduled for commissioning in 1965, will be a forced-flow, "once-through" unit having no steam-drum, the water being heated and evaporated, and the steam superheated, in a single passage through the multiple tube banks of the boiler. The boiler will supply 2,500,000 lb. steam per hour to a 375MW turbo-generator at a pressure of 3,650 lb per square inch gauge and a temperature of 1,110 deg. Fah., a high proportion of the steam being returned to the boiler, after partial expansion in the turbine, for reheat to a temperature of 1,055 deg. Fah. at a pressure of 713 lb per square inch gauge. Fuel will be fed to the boiler through large-capacity, ball type, pulverising mills of a new design developed by the company.

Operating at the same steam conditions, the boiler to be supplied by International Combustion Ltd., is a "once-through" unit designed in Great Britain in collaboration with Sulzer Brothers, Switzerland, and Combustion Engineering Inc., U.S.A. Tangential firing has been adopted, the streams of coal and air being directed to an imaginary circle in the centre of the fully-cooled combustion chamber by burners in the corners taking their supply from Lopulco mills. Allowance is made for one mill to be available at all times to meet any maintenance requirements. Fully-automatic control of the unit will be provided both for the feed water, steam temperature, reheat temperature and by-pass system.

The A.E.I. turbine will be of four-cylinder tandem-compound design. The high-pressure and intermediate cylinders will be single flow, and the two low-pressure cylinders will be double-flow, exhausting to twin condensers. Double casing will be employed in the h.p. and i.p. cylinders. The rotors, all of monobloc construction, will be solid-coupled. Turbine bearings will comprise six spherically-seated journal bearings and one separate thrust bearing in the intermediate pedestal. The turbine will be direct coupled to the generator, rotating at 3000 r.p.m. Eight-stage feed heating will provide a final feed-water temperature of 505 ± 5 deg. Fah.

The turbine will incorporate the A.E.I.–Baumann multi-exhaust system in which a proportion of the steam leaving the penultimate blades is deflected to the exhaust casing. This system provides an exhaust area that will enable the last blade length to be reduced to 29½in on a mean diameter of 83in. The tip speed that will result from this arrangement will mean that stresses will not significantly exceed those in machines now in service. Austenitic materials will be used in the high temperature parts of the turbine. The generator will incorporate hydrogen cooling and direct water-cooling of the stator winding. The stator will be of cage-core design to permit shipment in two parts. Operation will be assisted by turbovisory gear incorporating static systems.

In addition to the turbine-generator, A.E.I. is supplying twin condensers. feedheaters and boiler feed pumps. The feed heating system will have eight bled steam stages and the condensers will have double plate construction to prevent contamination of the condensate with cooling water.

The English Electric set comprises a multi-cylinder 3000 r.p.m. reheat turbine with quadruple exhaust arranged as a tandem compound unit coupled to a hydrogen/water-cooled alternator with direct cooled conductors. Solid couplings are employed between rotors and each shaft is mounted on two main bearings to simplify assembly and maintenance of the machine. Automatic shaft gland packing is incorporated.

The vacuum at maximum and continuous rating is 28·7in Hg (Bar. 30in). To meet the specified supercritical pressure and temperature requirements, the h.p. cylinder employs a double casing arrangement over the first stages with the expanded steam passing over the outside of the inner casing to pass through the remaining stages. Well proved ferritic materials are used in these casings and stress levels are such as to keep creep deformation well within permissible limits. Castings are used for the steam chests and cylinder casings as they provide a more uniform thickness of material and corresponding thermal response, thus avoiding transient distortion associated with temperature changes.

The intermediate pressure cylinder has a partial double casing construction similar to the high pressure cylinder. The quadruple-flow low-pressure cylinder is arranged in two double-flow low-pressure casings exhausting to one of the two condensers forming the twin condenser unit. In the case of the low-pressure cylinders ample area is provided in the four flows as each employs a last blade of 36in effective length on a mean diameter of 100in. The condensing plant includes twin-shell condensers which employ double plate construction to prevent contamination of the condensate by the cooling water, the space between the tube plates being sealed by condensate under pressure.

The alternator is direct cooled, having water-cooled stator conductors and a hydrogen-cooled rotor, the rated gas pressure being 45 lb per square inch gauge. With a maximum continuous rating of 375MW, the running speed is 3000 r.p.m., the power factor being 0·85.

The feed heating system has eight bled steam stages. The low-pressure heaters are on the suction side of the booster feed pump and the high-pressure heaters interposed between the booster feed pumps and the main boiler feed pump. The contract also includes a main boiler feed pump driven by an auxiliary steam turbine.

LITERATURE

Third International Congress of the Federation Internationale de la Precontrainte. Two volumes—Papers and Discussion. Edited by RALPH P. ANDREW, M.A., Ph.D. Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1. Price £13 a set: for members of groups affiliated to the F.I.P. £10 a set.

THIS book, which is the record of the Berlin Congress on pre-stressed concrete, is divided into two parts. The first volume of some 750 pages is the collection of papers presented there ; the second contains the discussion. In an endeavour to put some limit on the scope of the congress, papers were invited under three headings : developments in design methods ; progress in the technique of pre-stressing on site ; progress in the manufacture of factory-made units and their use on site. A session describing structures erected since the last congress is only briefly noted since it was largely devoted to the showing of slides (a film strip is available).

All the papers and the contributions to the discussion are printed in their original language with very brief summaries in the four languages allowed at the congress, namely English, French, German and Spanish. This treatment results in a handlable volume, but not in the erudition of those not gifted with languages. Fortunately, the general reports are in the four languages, but the titles of the papers could also, perhaps with advantage, have been treated in the same way.

In the first session the papers are largely devoted to " basic " design ; by far the greater number are concerned with the problem of shear and there is one on torsion. Although new data are presented it is clear that the mechanism of shear failure is not yet fully understood. These papers are very adequately summarised by Professor Rüsch, the general reporter of this session. This session includes, too, an interesting paper on the action of unstressed concrete in composite structures by Mikhailov of the U.S.S.R., part of which appears to confirm Abeles' work in this field. The remaining papers are not of very great interest.

The papers in the second are a little disappointing, perhaps because the approach to the practical problems seems to be national rather than international in character ; hence the experience of one country (except for the composition of grout) does not appear to be often relevant to another. Similarly, cables and stressing mechanisms are often different. It is clear from these papers that the problems of grouting and of friction have not yet been solved, but since rapid progress is still being made in the use of pre-stressed concrete one wonders whether, except in certain circumstances, they are not " problems " similar to those encountered in the early days of reinforced concrete which disappeared as practice placed them in their proper perspective. It is clear that what is important in one country is not so in another and that probably the major difficulties caused by friction arise in the design office rather than in the field. In various other papers different new anchorages are described, but again these appear to be of national rather than international interest.

The third session, being devoted to descriptive papers, depended on what the authors chose to illustrate rather than what had been accomplished in the different countries. To echo the general reporter's remarks, it is a great pity that national reports are not the rule but the exception ; obviously, personal prestige has entered this field. In the papers will be found descriptions of the Russian method of pretensioning, using a machine capable of continuously winding a pre-stressing wire, and of the American method of the deflecting strand in pretensioning beds. The general impression from the papers is that with the possible exception of space structures the method of construction has settled into a routine in the field of precast units.

The second volume, of some 200 pages, records the discussion under the same three headings. Again no translations are available, not even of the general reporter's remarks, so one does wonder how much immediate use will be made of it—no doubt, however, the relevant portions will be eventually quoted in English technical articles to the gain of British engineers. It is not easy to sum up this volume as the contributions are rather uneven in quality and one has the suspicion that there is worthwhile work being done which is not recorded here. Nevertheless it is a record of what was said and does give a picture of the lines on which different people are working.

The Cement and Concrete Association is to be congratulated on publishing so well produced a book in such a relatively short time. Yet one feels that more thought must still be given to the means of communicating to individual countries the results of an international congress. The problem at the moment seems almost insoluble without enormous cost and delay in publication.

Atomkraft. By FRIEDRICH MÜNZINGER. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, W. Germany. Price DM.42.

IN the three years which have passed since the publication of the second edition of *Atomkraft* by Dr. Friedrich Münzinger, considerable strides forward have been made in the science and technology of the industrial applications of atomic energy. The author has therefore completely revised and extended the book to bring it up to date with the latest developments. *Atomkraft* has been written as a critical introduction to the industrial uses of nuclear power and professes to be aimed mainly at engineers, political economists and politicians. The technical content of the book is not sufficiently detailed to provide the engineer with a sound knowledge of nuclear engineering, but it certainly represents a very useful introduction. On the other hand, political economists and politicians may be rather overwhelmed by the opening theoretical and technical sections.

The book is divided roughly into four sections ; first, a theoretical section, which describes the fundamentals of reactor physics, shielding, reactor control, containment, heat transfer and nuclear materials. The second section is of a more practical nature and describes the various reactor types now in operation, under construction, or planned, together with the alternatives available for the utilisation of the thermal power of the reactor, such as by gas, water, or liquid metal cooling, and by steam or gas turbines. The third section, on economics, is the most interesting one, and considers in detail the costs of nuclear power production, fuel enrichment and the economic prospects of nuclear power in Germany. The author reviews the plans for the expansion of nuclear power in America, Britain, Russia and France, and compares these with future German electricity requirements and costs.

The final section considers the possible applications of nuclear energy as the driving power for ships, aeroplanes, rockets, locomotives, and even towing units for long caravans of trailers. The advantages and disadvantages of marine reactors, their design, economic and commercial prospects are discussed, and the proposed reactor types are described.

The theme throughout the book is representative of the cautious approach of Germany towards atomic energy. The economic shortcomings are emphasised, together with the need to avoid embarking on a construction programme of diverse reactor types with little hope of financial return. The 304 pages of the book are liberally illustrated by a total of 259 figures and eighty-three tables, most of which have drawn from American and British sources. The author does not claim to have written a textbook, but has succeeded in providing engineers with a useful introduction to nuclear power, whilst he has taken politicians and political economists as far along the technical road as they are likely to desire or need to travel.

American Building Art—The Nineteenth Century. By CARL W. CONDIT. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 87s. 6d.

THIS, the first of two volumes, is a description of the civil and structural engineering achievements in the U.S.A. during the nineteenth century. The method of presentation, although appearing a little illogical to start with, justifies itself very quickly. It traces the history of various structural forms, such as bridge trusses constructed in various materials e.g. timber or steel, subdividing the form and material into different chapters.

Professor Condit obviously knows his material intimately and after what might appear (to some) a somewhat tedious beginning presents an interesting and instructive story. It is clear that except in the fields of multi-storey buildings, rope suspension bridges and perhaps reinforced concrete, engineering followed several decades behind European practice, but none-the-less an account of the fertility of man's mind when applied to engineering structures is always worth recording.

How often it seems we have to learn the same lessons time and time again, e.g. the bridge failures during erection. Some of the text has an up-to-date ring about it.

The book, too, is interesting in recalling the names of engineers, some of them English, some Continental, but many more native-born who made their reputation under great difficulties in opening up that vast country.

How interesting to read how Roebling imported English wire for his suspension bridges and how English cement was used in the early concrete work; to read, too, of some of the short erection times makes one blush for modern-day methods!

The history of the skyscraper, the suspension bridge and the early reinforced concrete

work are particularly fascinating and worthwhile to study. Time and time again one reads of things attempted which recall recent projects and one begins to wonder whether there is any new thing under the sun.

In conclusion it may be said that if one is interested in the history of engineering—and every engineer should be—this is an excellent book written quite dispassionately giving a fine appraisal of American ingenuity with many a side glance at contemporary European practice.

Konstruktionen und Bauelemente von Strömungsmaschinen. By Dr.-Ing. H. PETERMANN. Berlin-Göttingen-Heidelberg : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger-Platz 3. Price DM.12.

AT many technical universities and colleges, hydro- and aero-dynamic machines are dealt with collectively not only in the lectures but also in design practice. This is a natural procedure, as the same theoretical considerations are usually valid over a wide range of designs which have been evolved for the most differing purposes. In order to enable students to profit from their design work, they must have available examples of solutions from actual practice, and if the work is approached as mentioned above, the various machines should not be dealt with consecutively, but the characteristic features belonging to several classes of machines should be collected together. This has now been done for hydro- and aero-dynamic machines. Chapter headings of the present work list the following topics : rotors, guides and stators, manufacture of blades, axial thrust compensation, cooling and heating, casings and their components, and glands (as well as glandless designs). The subject matter is presented entirely by means of illustrations, for the most part sectional line drawings, the text being confined to long captions. In every instance the name of the firm responsible is indicated, and a list at the end of the book quotes the textbooks and journals from which information was taken. Although it would detract from an otherwise wholly admirable conciseness, it may be hoped that it will be found possible to include, in any future edition of the book, a list of references quoted in full, as well as a mention of the year of origin, and, in the case of major items, the project or installation of which they form a part, as this would assist those students who wished to delve deeper into any particular aspect of the subject.

Civil Engineering Today. By ROLT HAMMOND, A.M.I.C.E. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 21s.

THIS volume is one of a series called *The Pageant of Progress*, which deals with various broan subjects under similar titles, e.g. *Motor Cars Today*, and *Plastics Today*. It therefore gives essentially a lay account of the civil engineering industry, which the author attempts under the headings of " Foundation Engineering," " Mechanisation in Civil Engineering," " Tunnel Engineering," " Bridge Engineering," " Harbours, Seaways and Canals," " Highway Engineering " and " Problems of Railway Civil Engineering." Structures, apart from bridges, are not dealt with, nor are water supply, main drainage, hydro-electric and irrigation schemes, except as they occur incidentally to the main headings listed above ; there is, however, a final chapter called " Lessons Derived from Engineering Failures." The book is well illustrated, and is noteworthy in that the word " today " in the title has been emphasised in the choice of examples and subject matter.

Gasturbinen—Arbeitsweise, Gestaltung und Anwendung. By Professor Dr.-Ing. K. LEIST. No. 22 of the TR special series. Berne : Verlag Technische Rundschau, Hallwag Bern, Nordring 4. Price S.Fr. 5.80.

THE present volume of the TR special series represents one of the last writings of Professor Leist, the well-known German engineer, who for many years until his death on May 10 held the chair for gas turbine technology at Aachen, as well as the directorship of the Institute for Jet Engineers of the DVL. After a brief historical survey, the author discusses the principles of operation of the gas turbine which determine the thermal efficiency of a gas turbine plant. Efficiency in relation to the high temperature endurance of the blading, and the choice of fuels from the economic standpoint, are treated in special sections. The remainder of the book is devoted to the discussion of various typical forms of gas turbine, from the small industrial turbine to large stationary, aero, and ship's engines. Extensive references to literature are given in an appendix, which serious students of the subject will find particularly useful.

Mineral Use Guide. By R. H. S. ROBERTSON. Cleaver-Hume Press, Ltd., 31, Wrights Lane, Kensington, London, W.8. Price 21s.

THIRTY-TWO diagrams — " Robertson's spider's webs " they are called—are given to show at a glance the main uses of a rock or mineral. Fifty-two rocks and minerals are treated in this way, the general scheme of the " spider's web " being to name the raw material in the centre, list the common processes by which it is prepared in the innermost ring of the diagram, its chief physical properties in the second ring, and its corresponding applications in the third or outer ring. A glossary of terms is given.

Das Waagerecht-Bohr und Fräswerk und seine Anwendung. By H. SCHALLBROCH. Berlin-Göttingen-Heidelberg : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM.26·70.

THE present volume has been published on behalf of the German machine tool firm, Scharmann and Co., Reydt (Rhld.) on the occasion of the seventy-fifth anniversary of its foundation. Although the book draws extensively for its illustrations on the range of horizontal boring and milling machines in which the company specialises, machines by other makers are also referred to in the appropriate sections. The book constitutes a valuable compendium concerning the evolution and various present-day forms of this important type of machine tool ; while the production engineer will here find a description of standard and special operations for which horizontal boring mills are used together with numerical data for optimum cutting conditions. An extensive list of references covers the literature from the early years of the century to the present day.

Foundry Engineering. By H. F. TAYLOR, M. C. FLEMINGS and J. WULFF. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 78s.

THIS book, written by three lecturers at the Massachusetts Institute of Technology in the United States, is concerned with the basic engineering aspects of the materials and methods involved in making castings. It is intended primarily as an introductory college textbook and in a simple straightforward manner explains what a casting is, how it is made and the properties of castings. Sections dealing with refractories, metal melting, sand preparation and reclamation, welding, and heat-treatment, supplement the general treatment of the subject.

Books of Reference

Register of the Gas Industry, 1960. Gas Publications, Ltd., 157, Hagden Lane, Watford. Price 25s.—The directory section of this volume lists the national bodies and associations concerned with the gas industry and gives full particulars of gas undertakings in the United Kingdom, Canada, Australia and New Zealand. The technical section is divided into three parts concerned with various aspects of gas production, distribution and utilisation.

Guide to the Coalfields, 1960. Edited by R. H. Walkerdine, A.M.I.M.E., and E. E. Corbin. London : Colliery Guardian Company, Ltd., 30, Furnival Street, London, E.C.4. Price 20s.—This reference book again gives up-to-date particulars of the precise locality, personnel, class of mineral, &c., of the deep mines operated by the National Coal Board and licensees and non-coalmines which are subjected to the Coal Mines Act. Extensive revisions have been made to the lists in the light of reorganisations in the structure of the National Coal Board and a new section gives lists of the Board's brickworks, briquetting plants and coke ovens.

Colliery Year Book and Coal Trades Directory, 1960. Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 40s.—The thirty-eighth edition of this year book follows the general pattern of previous editions with the data and information brought up to date. The recent changes in the National Coal Board are included and more space has been given to the Mines Regulations in order to include current details of general legislation. There have also been added the complete Quarries (Explosives) Regulations, 1959, which came into operation in February last.

Books Received

Refrigeration Controls. By Harold H. Egginton. Refrigeration Press, Ltd., 131, Great Suffolk Street, London, S.E.1. Price 15s.

Safety on the Site. By B. A. C. Whyte. United Trade Press, Ltd., 9, Gough Square, Fleet Street, London, E.C.4. Price 20s.

Roads and their Traffic. Edited by E. Davies. Blackie and Son, Ltd., 16-18, William IV Street, London, W.C.2. Price 35s.

Engineering Data Processing System Design. By A. D. Even. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 49s.

High Voltage Direct Current Power Transmission. By Colin Adamson and N. G. Hingorani. Garraway Ltd., 11, Kensington Church Street, London, W.8. Price 84s.

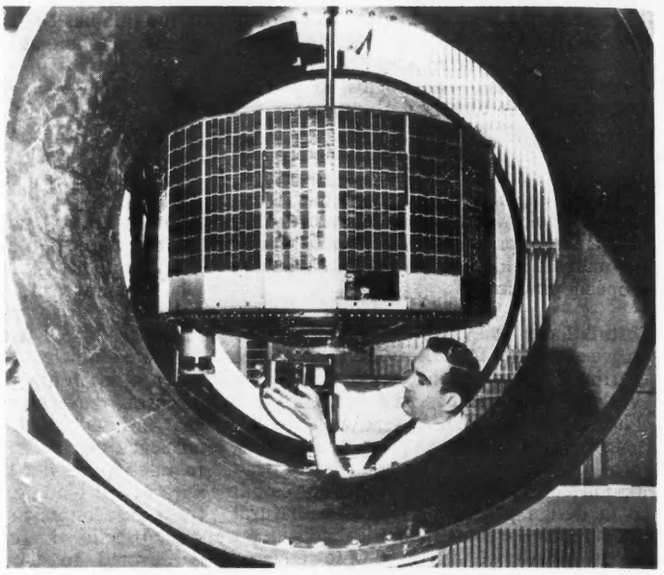
Ordinary Differential Equations and their Solutions. By George M. Murphy. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 64s.

Radioisotopes: a New Tool for Industry. Second Edition. By Sidney Jefferson. George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 21s.

Fluid Power Control. Edited by John F. Blackburn, Gerhard Reethof and J. Lowen Shearer. John Wiley and Sons, Inc., New York. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 140s.

Electromagnetic Fields, Energy and Forces. By Robert M. Fano, Lan Jen Chu and Richard B. Adler. John Wiley and Sons, Inc., New York. Chapman and Hall, Ltd., 37 Essex Street, London, W.C.2. Price 96s.

Mathematical Methods for Digital Computers. Edited by Anthony Ralston and Herbert S. Wilf. John Wiley and Sons Inc., New York. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 72s.



Silicon Cells and Solar Energy

This article is abstracted from a paper by Messrs. C. A. Escoffery and Werner Luft of the International Rectifier Corporation, El Segundo, California. Silicon solar cells which directly convert solar radiation into electrical energy have now been developed with conversion efficiencies of 12 per cent or more. The basic theory, and recent applications, such as in the "Tiros" weather satellite shown right prior to its launching, are discussed.

IN 1954, the P-N junction silicon photovoltaic cell was announced* capable of converting sunlight directly into electricity with an efficiency as high as 6 per cent. This development marked a significant advance in man's efforts to capture and utilise solar energy, for it was more than ten times the conversion efficiency of the selenium cell, the best previously known photovoltaic converter.

Since that time, considerable research has been made on the manufacture and application of the silicon cell and conversion efficiencies of over 14 per cent have been reported. The most widely used size is a rectangle, 1cm by 2cm, illustrated in Fig. 1 (standard design). Such cells are available commercially in large quantities with conversion efficiencies as high as 12 per cent.

Improved conversion efficiency in the silicon cell can be obtained by means of narrow grids which improve the collection of photo-generated current carriers. In one technique, illustrated as the improved design in Fig. 1, a thin aluminium wire loop is fused to the top exposed surface. The reduction in active area is negligible whereas the output voltage and power increase markedly and the voltage-current graph becomes more rectangular.

The maximum theoretical conversion efficiency of solar energy by means of the silicon cell has been calculated by various authors. Because of the nature of sunlight and of silicon, it is estimated to be about 20 per cent at room temperature.

Based on an atmospheric transmission coefficient of 0·62, it has been estimated that 32,000 times as much energy falls on the earth's surface as is at present utilised in all human devices. Expressed another way, if we could harness, at 100 per cent efficiency, all the solar energy that falls on slightly more than 16,000 square kilometres, we could supply all our current needs.

The direct collection of solar energy as heat is, at present, much more efficient than the conversion into other forms of energy and the temperature of the collector can be comparatively low if the energy is to be used for the heating of homes and buildings. But the direct conversion of solar energy into electricity is the most attractive process for performing useful work and silicon solar cells are already being widely used in an increasing number of applications. One of the most dramatic is their role in supplying secondary power to space vehicles and earth satellites, and it is quite possible that the hope for the large-scale terrestrial conversion of sunshine into useful energy may reside in the photovoltaic process.

* See THE ENGINEER, June 4, 1954, page 834.

Principles of Silicon Solar Cells

A photovoltaic converter, such as the silicon solar cell, directly transforms solar radiation into electric power without an intermediate heat cycle. The absence of moving parts, the lightness in weight, the simplicity and reliability of operation, and the indefinite life expectance, make the process extremely attractive. Although many other materials are capable of generating electric power under the influence of light, at the present time silicon yields the most efficient and most highly developed cells.

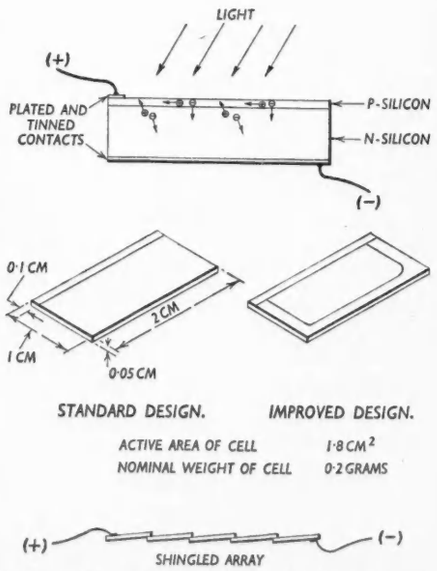


Fig. 1—Schematic representation of silicon solar cells

When used for semiconductor devices like rectifiers, transistors and solar cells, silicon must be refined and highly purified, often to impurity levels of one part per billion. In addition, it is necessary to prepare it in mono-crystalline form in order to take full advantage of its electronic properties.

In N-type silicon, which is prepared by doping with minute amounts of a Group V element (phosphorus, antimony or arsenic), the electric current is carried mainly by electrons. On the other hand, P-type silicon conducts mainly by positive "holes" (absence of electrons). It is prepared by introducing a Group III element (indium, aluminium or boron) into the silicon crystal lattice.

When both types of silicon exist in the same crystal we have the P-N junction, a phase boundary of considerable practical and theoretical interest. The P-N junction in a solar cell enables it to convert solar radiation into an electric current.

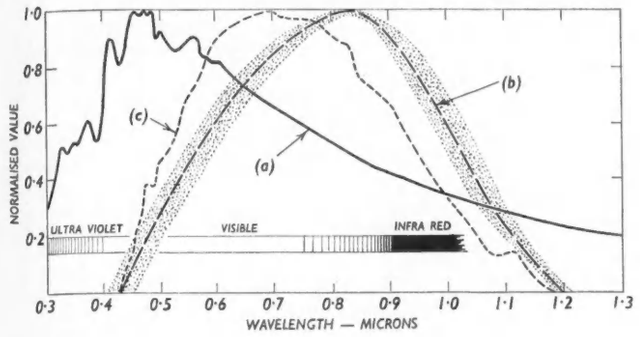
In one method of manufacturing solar cells, thin wafers of N-type silicon are carefully cleaned and chemically etched, and then placed in a quartz tube furnace at a temperature of about 1150 deg. Cent. Herein, vapours of a boron compound are passed for several minutes over the silicon, where they decompose into elemental boron which diffuses into the surface creating a thin, P-type silicon layer approximately 2 microns thick.

After the wafers have cooled, the P-layer is removed from the sides and rear surface so as to expose the original N-silicon, and ohmic contacts are attached to both sides of the P-N junction by appropriate plating and soldering techniques. Fig. 1 (not drawn to scale) indicates a schematic representation of a silicon solar cell.

The spectral response of silicon solar cells lies mainly in the visible and near-infra-red regions of the solar spectrum, as shown in Fig. 2. Incident radiation of wavelength shorter than about 1·1 microns is capable of being absorbed in the top portion of the solar cell and being directly converted into electricity.

The photons of light which are absorbed in the silicon crystal excite electrons, which move about leaving behind positively charged "holes." As a result of the electrical state of affairs at the P-N junction, a built-in electrostatic potential exists which plays a vital part in the photovoltaic process.

Electron-hole pairs liberated near the P-N junction are attracted by this potential such that electrons move to the N-side and holes to the P-side. A voltage difference appears across the cell terminals and if the latter are connected by an external circuit, an electric current will flow and can be made to do useful work.



(*a*) Normalised solar energy distribution at zero air mass (F. S. Johnson).
(*b*) Normalised spectral response (short circuit current) of silicon cells for equal energy input, typical range.
(*c*) Normalised spectral response of silicon cells to solar energy at zero air mass.

Fig. 2—Solar radiation and spectral response of silicon solar cells

Photoelectric Characteristics

Fig. 3 shows the voltage-current characteristics (at 100mW cm^{-2} irradiation intensity) for a high efficiency silicon solar cell of the standard design illustrated in Fig. 1. The irradiation used was obtained from a tungsten filament lamp operated at a colour temperature of about 2800 deg. K, and the illumination intensity was adjusted by a "standard" silicon solar cell, varying the lamp-to-cell distance until the "standard" cell yielded a short-circuit current equal to its calibrated value corresponding to 100mW cm^{-2}.

The "standard" cell is a carefully selected cell which has been calibrated by taking periodic readings outdoors in full sunlight using a pyrheliometer (radiometer with thermopile receiver) to measure the direct solar intensity. Since a linear relationship exists between short-circuit current and illumination intensity, the calibration values taken outdoors are normalised to 100mW cm^{-2}. In all cases, the cell temperature is maintained at about 30 deg. Cent. and cell voltages and currents are measured with a four-wire system.

Fig. 4 illustrates how the output characteristics of a solar cell vary with the amount of incident radiant power. For any given spectral distribution, variation of the short-circuit current is linear with radiation intensity. The same is approximately true for the output current at optimum power transfer except at low light intensities.

Solar radiation outside our atmosphere is more intense and of a broader spectral range than at the earth's surface. Since the intensity increase, however, occurs to some extent in spectral regions where the cell is not very sensitive, there is not a proportional

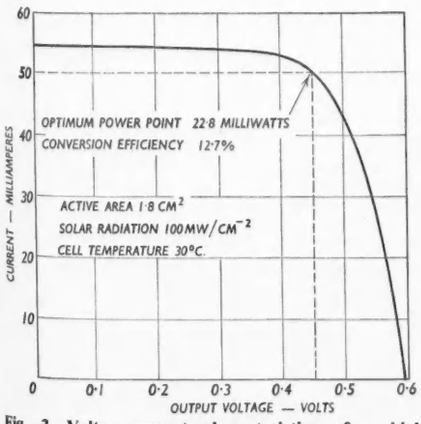


Fig. 3—Voltage-current characteristics of a high efficiency silicon solar cell

increase in cell output. Other things being equal, a solar cell calibrated on earth (at 100mW cm^{-2} solar radiation intensity) to delivery 10mW cm^{-2} with a conversion efficiency of 10 per cent, will deliver approximately 12mW cm^{-2} just outside the atmosphere (at 140mW cm^{-2}) with a conversion efficiency of about $8\frac{1}{2}$ per cent.

Fig. 5 illustrates the influence of temperature on the voltage-current characteristics of a silicon solar cell. At any given temperature, there is a certain matching load which yields optimum power transfer. In most applications, however, the load is constant (fixed resistance or fixed voltage), and the solar cells operate at less than optimum power transfer conditions as the temperature changes. Fig. 6 illustrates the effect of temperature on these three types of power output.

Solar cells are connected in series for increased voltage output and in parallel for increased current output. "Shingling," or overlapping of cells (Fig. 1) provides the highest output per unit area. In this assembly the entire exposed surface, with the exception of the collector strip on the end cell, is an active area. In many cases, it is preferable to mount the cells side by side in the same plane. In a series-connected string, the cell with the lowest current output will determine the overall current, hence care must be taken to ensure adequate current matching. For a parallel connection, voltage matching is more important.

Optical Characteristics

The spectral absorptance α_λ of the solar cell is defined as the ratio of the energy absorbed at each wavelength to that absorbed by a black body at the same temperature. Likewise, the spectral emittance ϵ_λ of the solar cell is defined as the ratio of the energy emitted at each wavelength to that emitted by a black body at the same temperature.

By Kirchoff's Law, α_λ and ϵ_λ are equal, and since the solar cell is opaque, they can be computed from measurements of the spectral reflectance† by subtracting from unity. Figs. 7 and 8 illustrate typical room temperature spectral reflectance values for silicon solar cells manufactured by the International Rectifier Corporation.

From Fig. 7 it can be seen that in the spectral region where the cells are effective converters, the reflectance is quite low, for instance, less than 4 per cent at 0·75 micron. (Some cells have shown a reflectance at 0·75 micron as low as 2 per cent.). This low reflectance is not characteristic of silicon, which is usually considered to have a value of 30 per cent or more in this spectral region. On the other hand, as shown in Fig. 8, the solar cells unfortunately have a high reflectance at long wavelengths, where maximum emitted radiation would take place. It is probable that the boron used in doping creates a silicon alloy with "semi-metal" characteristics.

† Throughout this discussion, the reflectance is understood to indicate the value at near normal incidence. Spectral reflectance values are generally constant up to at least 15 deg.

The average total absorptance for solar radiation $\bar{\alpha}_S$ of a surface exposed to such radiation is defined as the ratio of the total solar energy absorbed to that absorbed by a black body at the same temperature.‡ With respect to solar radiation in space it is approximately given by the following equation :

$$\bar{\alpha}_s = \frac{\int_0^\infty \alpha_\lambda I_\lambda \lambda}{\int_0^\infty I_\lambda d\lambda} \quad . \quad . \quad . \quad . \quad (1)$$

Where I_λ is the solar radiation intensity at each wavelength, and α_λ is the spectral absorptance.

For solar radiation just outside the atmosphere (m=0), equation (1) can be approximated by :

$$\bar{\alpha}_S = \frac{\int_{0\cdot2}^{2\cdot5} \alpha_\lambda I_\lambda d\lambda}{\int_{0\cdot2}^{2\cdot5} I_\lambda d\lambda} \quad . \quad . \quad . \quad . \quad (2)$$

since over 96 per cent of the solar energy resides in the range 0·2 to 2·5 microns.

Equation (2) has been evaluated through point by point multiplication of Johnson's curve for solar radiation (Fig. 2) and values of spectral absorptance (Figs. 7 and 8), the integral then being determined with a

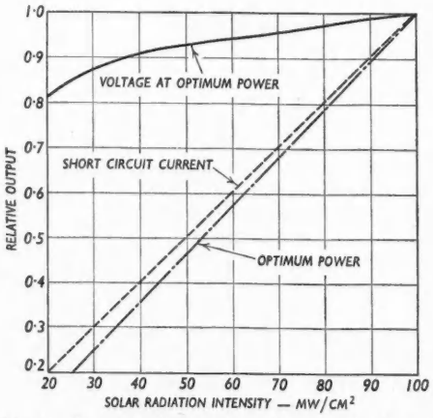


Fig. 4—Output of silicon solar cells as a function of solar radiation intensity

planimeter. The results indicate a α_S of 0·93 for silicon solar cells made by the International Rectifier Corporation.

The average total emittance $\bar{\epsilon}_T$ of a surface at temperature T is defined as the ratio of the integrated value of the energy emitted at each wavelength by the surface to that emitted by a black body at the same temperature. To a first approximation it is given by

$$\bar{\epsilon}_T = \frac{\int_0^\infty \epsilon_\lambda W_{\lambda T} d\lambda}{\int_0^\infty W_{\lambda T} d\lambda} \quad . \quad . \quad . \quad (3)$$

where $W_{\lambda T}$ is the radiant flux density emitted per unit wavelength increment at wavelength λ by a black body at temperature T, and ϵ_λ is the spectral emittance.

Because spectral data of ϵ_λ above 25 microns for solar cells are not available, equation (3) can be approximated by the following :

$$\bar{\epsilon}_T = \frac{\int_0^{25} \epsilon_\lambda W_{\lambda T} d\lambda}{\int_0^{25} W_{\lambda T} d\lambda} \cdot q + \epsilon' \cdot (1-q) \quad . \quad (4)$$

where q is the ratio of the radiant flux

‡ Actually, $\bar{\alpha}_s$ is also a slight function of temperature, but the subscript T is omitted in the interest of simplicity.

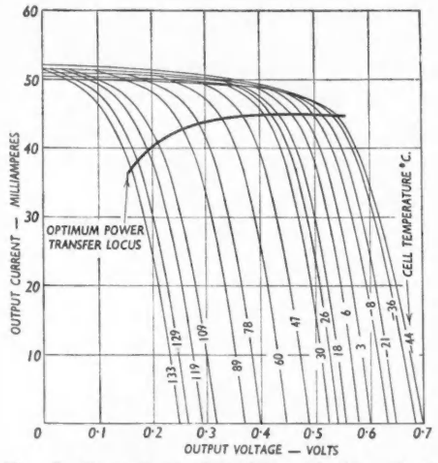


Fig. 5—Temperature dependence of the voltage-current characteristics of a silicon solar cell (1cm by 2cm size) with 10 per cent conversion efficiency at 100mW cm^{-2} solar radiation

emitted between 0 and 25 microns to the total radiant flux emitted, and ϵ' is a constant determined by extrapolation of ϵ_λ above 25 microns.

The value of q in equation (4) is 80, 86, 90, and 92·5 per cent for surface temperatures of 0 deg., 50 deg., 100 deg., and 150 deg. Cent. respectively. Values of $\bar{\epsilon}_T$ were not calculated below 0 deg. Cent. since due to the decreasing value of q, the second term in equation (4) increases, with a corresponding increase in the uncertainty of the calculation.

Using values of spectral emittance obtained from Fig. 8, and Planckian black body distribution curves for different temperatures, equation (4) was evaluated. The results indicate that the average total emittance for silicon solar cells manufactured by the International Rectifier Corporation is about 0·35.

Control of Solar Cell Temperature in Space

Since the power output of the silicon cell decreases with increase in temperature, it is important that the cell temperature rise be minimised through careful design of the solar energy converter system. Likewise, it is desirable, though not always feasible, to

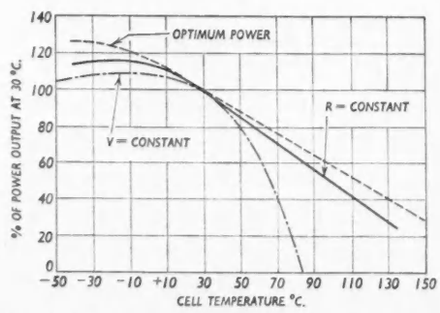


Fig. 6—Temperature dependence of the power output of silicon cells at constant load resistance, constant load voltage, and matched load (Normalised at 30 deg. Cent.)

minimise the temperature excursion from the temperature at which the output load has been matched.

As mentioned before, one of the widest applications for silicon solar cells is their use in space vehicles. The cells are usually attached to large sections of the vehicle and absorb most of the solar energy received, but only about 10 per cent of this energy is converted into electricity, the rest heating the cells and space vehicle. In turn, the temperature rise due to the heat serves to reduce the conversion efficiency even further.

At the present time, research is being conducted by various establishments to develop band pass filters having the reflective characteristics required. (The theory is outlined in the original paper.) Interference film filters are being used which are vacuum deposited on to glass cover slides and which have a 50 per cent transmittance at 0·45 micron, and below 0·4 micron the transmittance is negligible, part of which, however, is an actual absorption loss.

The glass cover slides which are cemented to the top surface of the solar cell can also be provided with films to reduce the reflection of the glass from about 4 per cent down to 2 per cent in the region between 0·5 and 1·2 microns.

(Further details of methods of increasing spectral reflectance and total emission are then given by the authors but not reproduced here.)

Applications

Silicon solar cells are being widely used in a large and growing number of applications which include auxiliary power for space vehicles ; battery chargers ; emergency or standby power supplies ; remote beacons and remote weather stations ; light sensors in various types of electronic equipment ; remote control ; switching, counting and sorting circuits ; transistorised equipment such as radios, portable transceivers and other types of communication equipment ; clocks ; navigation aids ; hearing aids ; warning light flashers ; neutron detectors and radioactive fission probes (solid state ionisation gauges) ; and experimentally even in such fields as the demineralisation of saline water and the electric automobile.

A large panel measuring about 2·4 square metres and comprising over 10,000 silicon cells of the 1cm by 2cm size has been made. Although the efficiency of the cells used was relatively small (about 5 per cent), sunlight falling on this panel was capable of lighting a 100W incandescent filament lamp. The panel was also mounted on the roof of a restored, antique electric automobile and used to charge its nominal 72V battery system.

The solar cell power supply for " Tiros I," the weather satellite shown in the heading illustration, that uses solar energy to power its television cameras and associated electronic equipment comprises over 9200 cells (1cm by 2cm), each one covered with an optical filter glass slide for temperature control. Sealed, rechargeable nickel-cadmium batteries are provided for energy storage.

One of the characteristics of silicon cells is their great lightness. The weight of a 1cm by 2cm silicon solar cell is about 0·2 gramme ; hence, a 12 per cent cell (1·8 square centimetre active area) delivering 21·6mW in full sunlight (100mW cm^{-2}) has a figure of merit of 108mW per gramme.

Since the life expectancy of the cell is believed to be indefinitely long, it is difficult to arrive at an energy per weight ratio. If a conservative value of 20,000 operating hours is used, we obtain a figure of 2·16kWh per gramme for unsupported cells of 12 per cent efficiency.

As with many other goods, costs of silicon solar cells vary with quality and quantity. Due to the high raw material costs for the purified silicon and to inherent processing losses in manufacture, they cannot compete at present with electric power produced by conventional methods except at relatively lower power levels and in remote or isolated places.

Significant decreases in cost have been made, and they are now available in quantity at about 50 dollars to 300 dollars per watt, depending on the efficiency and the quantity of the cells. Discounting the cost of auxiliary energy storage devices, medium efficiency cells (5 per cent) yield an energy cost figure over a life span of 20,000 hours of less than 5 dollars per kilowatt-hour. This is smaller than what is often paid for primary electrochemical cells, such as flashlight batteries.

The price is constantly dropping as the technology of manufacture improves and as the market increases. New processing techniques are being investigated for pro-

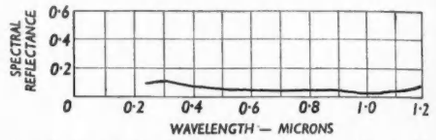


Fig. 7—Spectral reflectance below 1·2 microns for boron-doped silicon solar cell surface

ducing large area, medium efficiency silicon solar energy converters. One of these is based on the deposition of silicon P-N layers by means of the decomposition of suitable silicon compounds on heated substrates.

When these techniques are fully developed and translated into production and widespread use is made of them for the large-scale conversion of solar energy, it is expected that the cost may tumble to less than 5 dollars per watt. Again, spread over a life of 20,000 hours, this corresponds to an energy cost of 0·25 dollar per kilowatt-hour. We are obviously reaching the point where the main economic problem is one of reducing the cost of the energy storage systems which, though not needed in all applications, are necessary for supplying power at peak loads and in the absence of sunlight.

The intensive search being conducted on improved energy storage systems as well

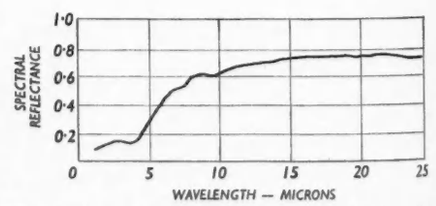


Fig. 8—Average total emittance ν. temperature for various solar cell surfaces

as on photovoltaic cells made from silicon and other materials leads to the hope that before long the photovoltaic conversion of solar energy will be widely used on earth to complement other sources of power.

Obituary

We record with regret the death of Mr. G. Maurice Wells, who died on August 10 in hospital after a short illness. Mr. Wells became a partner in Livesey and Henderson, Consulting Engineers, 1-2, Finsbury Square, London, E.C.2, on April 1 last year, having previously been the firm's chief engineer for many years.

SHORTER REPORTS

Report on Coal Derivatives

EARLY this week there was issued by the Ministry of Power the Report of the Committee on Coal Derivatives.* We print below the Committee's detailed conclusions and recommendations. Comment upon the report appears in a leading article on page 299.

GASIFICATION

New processes should show reasonable promise of producing town gas at not more than 10d. per therm, including capital charges, if they are to be capable of replacing existing ones.

The cost of making town gas at suitable sites on a large scale by the Lurgi process, with enrichment from petroleum sources, is sufficiently low to be attractive.

There is no commercial process available for making rich gas entirely from coal.

Cost rules out methanation as a means of enriching gas for most purposes.

We recommend that the present work on coal hydrogasification, to produce high calorific value gas from coal, should be continued on a small-scale pilot plant so that its potentialities can be accurately assessed.

The expansion of Lurgi gasification will depend on the ability to generate large volumes of gas at favourable sites. The development of a national grid, possibly linked with underground storage, would be a major factor in this expansion.

Although the development of high-pressure slagging gasifiers is at an early stage, the principle shows promise of considerable advantages. These advantages should make possible improvements in the technique of gasifying coal which in turn would lead to a significant reduction in the cost of gasifying coal. We recommend that development of these gasifiers should be pursued.

The time required for developing a slagging gasifier to a stage at which a prototype of a full-scale plant could be designed would be at least five years ; the further expenditure required to carry the project to this stage is likely to be of the order of £2,000,000.

To reduce the cost of synthesis gas the Ministry of Power has been working on slagging gasification. Currently, this work gives less emphasis than in the past to gasifying fine coal, and there may be technical and economic advantages in operating a slagging gasifier solely on graded coal ; these advantages have still to be established.

We endorse the decision of the Gas Council to install an experimental Otto-Rummel double-shaft gasifier.

Unless some entirely new and unforeseen technique is discovered, underground gasification is not an economic process in this country.

OIL-FROM-COAL PROCESSES

The hydrogenation of coal is a less economic route to oil than synthesis by the Fischer-Tropsch process.

The cost of making synthesis gas is the major part of the total cost of making oil from coal by the latter process.

In this country the cost of making synthesis gas from coal, even assuming a more efficient gasification process than is available now, would about equal the value of the products made by the Fischer-Tropsch synthesis from it. There would then be no margin to provide for the services, labour, maintenance and other operating charges or the capital charges of the synthesis process.

Design studies which we have considered show that oil products cannot be made from coal in commercial quantities without a very large annual subsidy.

It would be unwise to base a case for further work on oil from coal on the possibility of making highly priced speciality products.

Before building such plants, expenditure of the order of £10,000,000 to £20,000,000 on developing the necessary technology, including work on gasifiers and synthesis reactors, as well as the construction of pilot- and demonstration-scale plants would be required. We do not think this expenditure would be justified.

The results of the development on gasifiers which is already in hand should provide, in due course, a firm foundation for a better assessment of making oil from coal in the future, and we recommend the matter should be reviewed whenever a substantial advance is made in coal gasification.

We recommend that technological work on the Fischer-Tropsch process at the Warren Spring Laboratory should be wound up in about eighteen months' time when the objectives of the current programme have been reached. Basic work should then be intensified to cover new studies.

Close contact should be maintained with S.A.S.O.L. and any other industrial oil-from-coal projects.

CHEMICALS FROM COAL

The usage in this country of home-produced primary chemicals based on carbonaceous raw materials in 1958 was about 1,750,000 tons. Of this about 60 per cent was ultimately derived from coal. The total usage of coal as such for chemical processes (other than those based on the by-products of carbonisation) was about 1,500,000 tons.

In 1958 the carbonisation industries produced 85,000 tons of ammonia, 475,000 tons of crude benzole and 3,000,000 tons of tar. With a few important exceptions chemicals that could be extracted from crude benzole and tar are present in greater quantities than are currently required by the chemical industry. The problem which faces the distillation industry is that of producing chemicals at a competitive price and finding outlets for them, and continued work is needed on the extraction of such products as benzene and naphthalene.

Though there will be a large expansion in the use of aliphatic chemicals during the next ten years, the use of carbide may not increase proportionately.

The total amount of coke used for syntheses of all types other than via carbide in 1958 was about 900,000 tons requiring about 1,350,000 tons of coal.

By the late 1960s the synthesis gas requirements are likely to have doubled.

In the immediate future the cheapest method of making pure hydrogen for chemical purposes is likely to be the steam reforming of light naphtha.

Work on Lurgi gasification and on the slagging of coal gasifiers in general may help to improve the competitive position of coal for making synthesis gas for the chemical industry.

Work should be pursued on certain speculative processes.

INDUSTRIAL GAS

If the various gasifier developments which we have considered make it feasible for lean gas to be produced on a large scale cheaper than is possible at present there might be a substantial industrial market for gas with a minimum of purification.

There might be difficulties about having two separate gas distribution systems which we have not considered. But we note that the most effective exploitation of new complete gasification installations will call for a continuous review of the possibilities of long-distance gas transmission.

There is scope for further improvements in the design of single-stage gas producers.

Particular improvements have been achieved by the design of two-stage producers, and we consider that further work should be done on ways of increasing the variety of coals which can be used in these plants.

We recommend that work on the utilisation of producer gas should be continued.

We endorse the decision of the National Coal Board to install an experimental Ruhrgas producer.

ORGANISATION

The work required in the fields of coal tar and benzole refining is being adequately carried out, and we believe the effort—which will in the future have to include work on the increased extraction of benzene and naphthalene—will continue to be adequate.

The Gas Council should be responsible for further work on the standard Lurgi gasifier using British coals, on the Otto-Rummel gasifier, and on any further gasifiers suitable for town gas.

The Gas Council should also be responsible for development work on slagging gasifiers, though it will not be easy for them to take over the development work at present sponsored by the Ministry of Power.

While the various organisations concerned are discussing how responsibility for the work on slagging gasification is to be transferred to the Gas Council, this work should continue under present arrangements without interruption.

The National Coal Board should be responsible for research and development work on producer gas plants.

* H.M. Stationery Office. 4s.

Control of Corrosion

CORROSION and the considerable financial burden it imposes is a constant source of concern while the many unknown factors such as the state of the water, temperature, velocity, operating conditions and the nature of the materials through which the water circulates, offer problems difficult to overcome. Where water is contained by metal, corrosion generally exists and is principally induced by oxidation, electrolytic action, acids, salts and gases. Chemical additives, the provision of anodes, and other means have been adopted to cure or retard corrosive attack and a recent addition to the anti-corrosive preparations is " Aqua-Clear," which it is claimed can reliably protect water circulation systems and water tanks irrespective of the quality and temperature of the water. It is used in liquid form as an additive for closed circulation systems and ballast tanks while for continuous flow systems an " Aqua-Clear " feeder, holding the additive in hard crystal form is employed. Small quantities of the medium when dissolved in water produce a dense and protective glass-like film of microscopical thickness that will protect metal even against a degree of cavitation erosion. Corrosion will be halted by the additive, despite a bad state before treatment, and the compound does not adhere to itself so is not scale forming ; therefore since there is no tendency to build up in thickness there is no loss of heat transfer. It is stated that water containing " Aqua-Clear," despite its silicate content, will not harm bearings of reciprocating engines and turbines in the event of leakage, and that it has no effect upon lubricating oil. " Aqua-Clear " is an odourless, colourless, non-toxic liquid formulated to prevent the formation of rust and the discolorisation of water in any metal container. One pint of liquid " Aqua-Clear " should be added to each ton of water in the cooling system, and to ensure that the concentration is correct, the pH value of the coolant should lie between 8 and 9·5. For drinking water tanks two fluid ounces of the compound is added to every 100 gallons of water.

" Aqua-Clear " was developed by the Sudbury Laboratory, Massachusetts, and is imported by Murray McVinnie, Ltd., 1-19, West Street, Glasgow, C.5.

[Reply Card No. E3192]

SHORTER REPORTS *(Continued)*

Standards Associates

A NEW scheme for a "Register of Standards Associates," sponsored by the British Standards Institution, was given the support of more than 100 engineers and others concerned with the application of standards in industry at a meeting held recently in London under the chairmanship of Mr. H. A. R. Binney, director of the British Standards Institution.

The objects of the scheme were agreed to be "To provide a forum for those connected with standards matters, to increase knowledge and develop techniques in order to further the aims and practice of standardisation, generally through discussion and dissemination of information."

People joining the Register will become associates of the Institution. They will receive copies of the Institution's News each month, a list of the names on the Register from time to time, and it is hoped, says the Institution, a special bulletin. A Programme Committee made up of regional representatives will organise the programme of activities—local and regional meetings—whilst a Management Committee will be responsible for the scheme as a whole. It was agreed at the meeting that the existing Institute of Production/B.S.I. Committee on the use of standards in industry, enlarged by six members, would form the Management Committee.

Bearing Extractor

A TOOL for the extraction of all kinds of ball and roller bearings from shafts, which is made in Holland, is now marketed under the trade name "Tracta" in this country by G. E. Simm Engineering, Ltd., of Sheffield. When it is required to remove a bearing the extractor, to be seen in the illustration, is fitted with one of a range

Ball and roller bearing extractor set

of collets to suit the bearing size. The collet is slipped over the inner ring of the bearing so that teeth at its end fit into the ball groove between the balls. As the chuck of the tool is then tightened the collet is compressed, causing its teeth to grip the bearing inner ring.

With the inner ring gripped, the spindle of the tool is then screwed down into contact with the shaft end and its continued rotation draws back the body of the extractor, together with the bearing. To facilitate the removal of bearings some distance from the end of a shaft, extension tubes can be fitted on the tool. For the removal of bearings of over 3in bore a hydraulically-operated tool with a similar working principle is available.

[Reply Card No. E3202]

Plutonium-in-Air Monitor

A PLUTONIUM-IN-AIR monitor which is believed to be unique is one of the nucleonic instruments that the Atomic Weapons Research Establishment, Aldermaston, will be exhibiting at the fifth International Instruments and Measurements Conference, Stockholm, September 13–16.

By continuously sampling air for plutonium alpha activity, this monitor gives a rapid warning of the release of plutonium into the atmosphere. In this instrument the plutonium dust particles are impacted on to a zinc sulphide coated film that is measured continuously with an alpha scintillation counter. The impactor collects particles of about 1 micron in size, such as those of plutonium, more readily than it does smaller particles like those of radon or thoron decay products, which are swept through. Its discrimination efficiency in favour of the larger particles is about 10 to 1.

Sampling is carried out for preset periods (e.g. ten minutes) and the integral count is recorded at the end of each period. The sampling unit incorporates the demountable impactor assembly, film spools, scintillation counter, actuator mechanism and safeguard circuits. The impactor is connected by a short length of plastic hose, of 2·5cm bore, to a blower unit which gives a sampling rate of 18 to 20 cubic feet of air per minute. The remote control and alarm unit, which is rack mounted, contains four main circuits : timing, scaling, alarm trip, and power supplies.

When the monitor is in operation the pulses from the scintillation counter are integrated at the remote scaler, the alarm trip circuit being preset to operate at a known number of counts equivalent to a particular concentration of plutonium in air. In the instrument to be shown at Stockholm there is both aural and visual indication but the alarm could equally be arranged to trigger some other device directly ; for example, a reactor control mechanism.

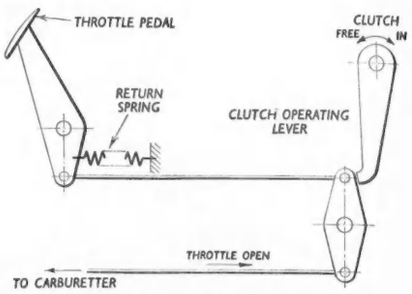
If the preset integral count is not reached in the preset period, the timing circuit shuts off the blower and the scintillation film moves forward to expose a new section of zinc sulphide to the impactor. The scaler is reset, the blower restarted, and a new count commenced.

"Fail-safe" provisions come into effect if there should be no counts integrated during the preset period or if there should be any failure of the film drive.

Automatic Clutch Operation

A SYSTEM of clutch control for vehicles which effects engagement and disengagement of a conventional clutch without any conscious effort by the driver has been developed and patented by Mr. R. Hadekel, B.Sc., A.F.R.Ae.S., M.I.Mech.E., and Mr. J. R. Herbert, B.Sc. It is suitable for vehicles in which the clutch operating effort is low and in which the work available to actuate the accelerator is large, i.e. small-engined vehicles with foot throttles. The principle is extremely simple, as our diagram shows: the accelerator pedal return spring is made strong, and is arranged to disengage the clutch when the accelerator is released. The linkage is so designed that the torque absorbed by the clutch increases as the throttle is opened: clearly, the relationship between engine torque and throttle opening is not unique, but a satisfactory operating line can be achieved, and, we are advised, does not require re-adjustment more frequently than, say, the tick-over. The optimum relationship between clutch arm and throttle movement is, of course, different for moving off from rest and for changing gear, but an adjustment for the position of the fulcrum on the lever could be provided and is, in fact, envisaged in order to allow engine braking to be obtained. Engine braking is in any case available by changing down and opening the throttle and, if necessary, turning off the ignition.

Without this slight complication, it will be clear that with this device incorporated, a vehicle handles as if it had a freewheel (while a freewheel would be equally effective as far as gear changing is concerned, it would not afford two pedal control unless an automatic clutch was provided, so that it does not rival the new system in respect



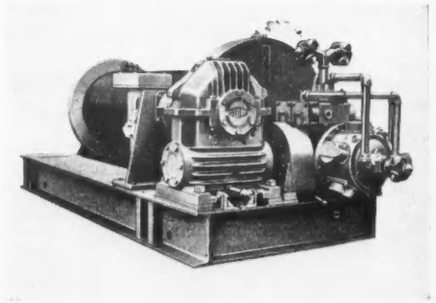
Principle of clutch-pedal-less control

of cost.) The design difficulties are not severe, being principally those of making a linkage from the driver's pedal to the clutch that will transmit rather large loads with high efficiency (in order to keep the accelerator force and travel reasonable.) Driving requires little skill, particularly for those accustomed to changing gear with the throttle pedal released : the most favourable style is that associated with heavy vehicles, of selecting either full or idling torque, since at some small throttle opening clutch slip will occur. The only distinctive technique is that of starting on steep adverse gradients ; engine speed is built up in neutral, the throttle released and the gear engaged rapidly, and the throttle opened again while the engine speed is still high. As this indicates, the device is particularly adapted to vehicles with synchromesh on all forward gears, like the Continental light cars. The new system is likely to commend itself particularly on two-stroke vehicles, where the engine braking is both slight and uneven, and on existing designs being converted to two-pedal operation to suit drivers either physically handicapped or unable successfully to operate three pedals with two feet.

[Reply Card No. E3204]

Air Motor Driven Winch

OUR illustration shows a special-purpose pneumatic winch designed and built by Globe Pneumatic Engineering Company, Ltd., Ashton Road, Harold Hill, Romford, Essex, for use in flameproof areas. It is capable of exerting an 11-ton pull at a rope speed of 40ft per minute using an air pressure of 90 lb per square in.



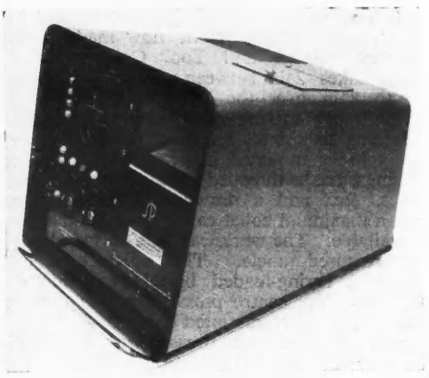
Pneumatic winch with all working parts enclosed

The winch is driven by twin radial piston air motors jointly developing 36 h.p. and coupled to a common shaft through a bevel gearbox. A cam on an extension to the drive actuates a stopping trip at the top and bottom limits of winching rope drum run. A pressure sensitive control valve is provided for remote operation of the winch and a fail-safe disc brake is fitted.

[Reply Card No. E3205]

Direct-Writing Oscillograph Recorder

THE twelve-channel oscillograph illustrated has been introduced by Savage and Parsons, Ltd., Watford, Herts, for recording at frequencies from direct current to 1000 c/s and above, within which range it is capable of recording any variable function which can be translated into



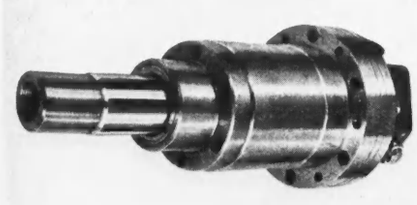
Twelve-channel oscillograph recorder with eight-speed drive for paper sensitive to ultra-violet light

an electrical signal. Fifteen mirror galvanometers are incorporated, the additional three channels serving for time or event marking, or as extra recording channels if required. A switch enables two of these three galvanometers to be connected with the mains supply to provide a reference frequency. The oscillograph employs a compact-source ultra-violet lamp, recording up to fifteen traces on sensitised paper 6in wide. Images are developed spontaneously within a few seconds. With standard galvanometers fitted in the instrument the response is up to 1000 c/s with a tolerance of ±1 per cent and a sensitivity of 7·5mA per centimetre. Other units are available to allow recording at frequencies up to nearly 2000 c/s.

Eight paper speeds, from 5in per minute to 150in a second, may be selected by the operation of push buttons on the front panel, the running speed being indicated by a light adjacent to the button which has been operated. All the gears are permanently meshed, speed selection be.ng made through solenoid clutches, so that speeds may be changed during recording. A footage selector switch stops the drive after 2ft, 5ft or 10ft of paper have been exposed, or allows continuous running. The top cover seen in the illustration gives access to a screwdriver adjustment for setting up the position of each trace on the paper, the effect being observed through the front window. Amplifiers and power units have been designed specially for the oscillograph, and if required can be assembled into modules for desk or rack mounting.

Hydraulically Driven Automatic Oscillating Device

A HYDRAULIC device for oscillating a piece of equipment with a controlled stroke and frequency, which has been developed by Hydraulic Machinery Drives, Ltd., Allesley, Coventry, is illustrated below. It consists essentially of a double acting hydraulic cylinder, the piston of



Hydraulic oscillator giving up to 2in reciprocation automatically at six to sixty strokes per minute. Its available force is one ton for a working pressure of 1000 lb per square inch

which has a stroke variable in increments of ¼in from ¼in to 2in. The maximum working pressure is 1000 lb per square inch with a maximum flow requirement of 1¼ gallons per minute for a 2in stroke at sixty strokes a minute. Stroke speed can be varied from six to sixty per minute and the maximum force available in either direction is 1 ton.

Reciprocation of the device is achieved by a built-in pilot-operated directional valve which supplies the pressure oil alternately to each side of the piston. By the incorporation of a small flow control valve it is possible to make the speed of reciprocation independent of load changes up to the maximum available.

Automatic Beryllium Monitor

A BERYLLIUM monitor designed and developed by M. S. W. Webb, R. J. Webb and P. C. Wildy of the United Kingdom Atomic Energy Authority's Woolwich outstation is being manufactured and marketed by Winston Electronics, Ltd., Shepperton, Middlesex, under licence from the Authority. The equipment, designated "4W," is automatic in operation, recording the beryllium content of a fresh sample of atmosphere every sixty seconds. Air to be sampled is drawn through a chamber in which any beryllium present is optically excited as it passes through a triggered a.c. arc. The ultra-violet radiations from this source are then resolved into their components by means of a spectrograph of high dispersive power. The intensity of the beryllium doublet at 3130Å deg., which is proportional to the concentration of beryllium present in the air being monitored, is measured photo-electrically and the ratio of the intensity of this doublet to the intensity of the adjacent background is recorded.

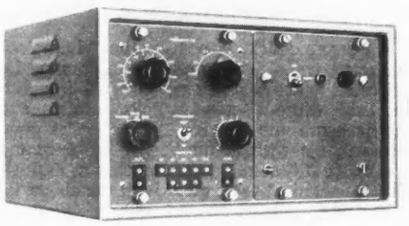
The arc chamber is designed so that the air sample is directed into the centre of the arc, and the placing of the electrodes ensures that airborne dust remains in the excitation zone for the maximum time. This chamber forms part of the sampling head, which is portable and connected to the main console by an air hose which also carries the electrical leads. Samples may, therefore, be taken at the inhalation level of an operator working on the metal or its alloys. An automatic calibration unit is built into the sampling head. The sampling head of the monitor measures 19in by 10in by 11in high, and the main console 21in by 24in by 54in high. This console houses the pump, power supply units, integrator-amplifier units, and recorder. It is a mobile console with the top panel sloped at 60 deg. to facilitate viewing and operation of the recorder and main controls. Power consumption is 2·5kW, and the unit is supplied for 230-240V or 110-130V mains, 40 to 60 c/s.

Test Waveform Generator

SQUARE-WAVE, sine-wave or ramp-wave signals for testing servo systems and for demonstration purposes are provided by the TWG100 waveform generator produced by Feedback, Ltd., Crowborough, Sussex, an associate company of Servomex Controls, Ltd. The accompanying illustration shows the frequency-setting controls, continuously adjustable from 0·03 to 30 c/s, at the top of the panel, with the waveform selector below and the alternative outlets for fixed outputs of 40V, 30V, 20V, and 10V peak-to-peak, and 0–5V (variable) peak-to-peak.

In addition to these normal test outputs, square and triangular waves of 10V peak-to-peak amplitude are continuously available. The square-wave is intended for oscilloscope synchronisation, and the triangular waveform to give an X deflection if an oscilloscope with direct access to the d.c. X channel is available. With this latter operation the display is automatically in synchronism with the test inputs and responses for all frequencies. Since the X deflection magnitude is constant, the trace may be interpreted directly in phase angle independent of frequency.

The generator uses an integration and switching circuit to produce the triangular and square waves, and the triangular waveform is shaped in a diode network to give a wave which is within 2 per cent of a true sine-wave. A further network generates the ramp-wave of alternate flats and slopes by removing the peaks from the triangular waveform. The square-and sine-waves are for transient and frequency response investigations, and the ramp-wave for investigating steady-state following performance. It is stated that the



Generator of square, sine or ramp waveforms for testing servo systems

equipment is particularly suitable for use with the Feedback ES1A servo system. The generator also incorporates a high-speed relay for switching two signals for comparative display on a single-beam oscilloscope.

Hydraulic Thrust Boring Machine

THE new hydraulic thrust boring machine illustrated below has been designed by E. Pass

Hand-operated hydraulic thrust boring machine for small pilot holes

and Co., Ltd., of Denton, Manchester, for boring pilot holes under roadways, drives and paths, &c., to accommodate services, cables and small diameter mains. It can be operated by one man with need for the minimum amount of excavation to enable thrust boring to be carried out without interrupting traffic on a roadway.

The machine, which is only 2ft long by 1ft wide, is capable of exerting a thrust load of 8 tons to the boring head. This head, supported by a large area thrust frame built into the unit, has a single ram operated by a twin-piston, double-acting, hydraulic pump housed in the main frame of the machine and connected by high-pressure flexible hose.

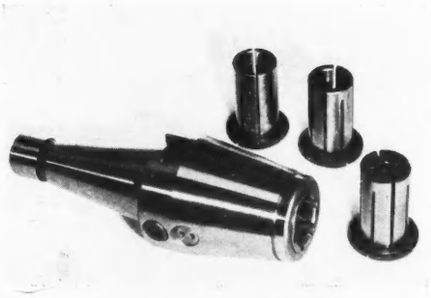
The carriage is spring returned and is actuated through a pressure relief valve conveniently arranged on the pump. Four thrust positions are provided on the carriage to facilitate the progressive entry of the boring head into the subsoil, and a retaining clamp is fitted to prevent the boring rod from lifting in the machine carriage during the thrusting operation. When a hole has been bored, the machine may be reversed in the excavation and the rods withdrawn, hauling with them the service or cable, which is held by a special adapter.

SHORTER REPORTS *(Continued)*

Collet Chuck

A COLLET chuck, known as the " Lamalock," marketed by A. A. Jones and Shipman, Ltd., Leicester, is designed for use with milling cutters and drills without screws or keys to lock the tool and transmit the torque. These collet chucks are available with a number of standard taper shanks to fit a range of machines and they take 1in shanked tools directly in the chuck bore or can be supplied with ¼in, ⅜in, ½in, ⅝in and ¾in collets for use with cutters having smaller shanks. A typical standard set is shown in our illustration.

The bore of the chuck is fitted with an internally grooved bush, part of the outer central length of which is recessed to form an annular chamber with the main bore. This chamber,



Pressure fluid locked collet chuck for use with cutters having plain ground shanks

sealed at each end by " O " seals, is filled with fluid and connected through a passage on the body of the chuck to a small cross bore, forming a hydraulic cylinder, machined in the back of the body. By screwing down a piston at the top of the hydraulic cylinder, pressure is applied by the fluid in the annular chamber over the whole area of the bore of the bush to close it in and impart grip on the tool shank. The contact area between the collet bore and the tool is such that the makers claim that a grip for a working torque of 250ft. can be obtained by finger-tip tightening of the piston key. It is stated that cutters with plain ground shanks can be changed in less than ten seconds when this design of collet chuck is used.

The chuck can be adopted as an adjustable boring head by using an eccentric sleeve to hold the shank of a cranked boring tool. In this case the outside diameter of the body can be calibrated relatively to the eccentricity of the collet to define its setting and angular rotation.

[Reply Card No. E3221]

Steel Chimneys

To overcome the problems of corrosion due to condensation in steel chimneys or flues, which can result from high boiler efficiencies and consequent low flue gas temperatures, the " Dribore " chimney has been developed by Superwelds (Lewisham), Ltd., Princes Road, Dartford, Kent, in association with the British Petroleum Company's Research Centre at Sunbury. It is claimed that in this design of chimney the cause of corrosion—condensation—is removed by maintaining the inner surface of the chimney above the dew point of the flue gas. The design principle is quite simple in that the chimney consists of two concentric sections, forming a double skin, separated by an air gap in which there is contained a reflective insulating medium.

The thickness of the mild steel used for the inner and outer skins varies with the diameter of the chimney and can be from 12 gauge for chimneys up to 14in diameter to $\frac{3}{16}$in thick for large chimneys. It is claimed that the stayed double skin gives greater structural strength than ordinary forms of construction in equivalent sizes and, since wastage due to condensation is virtually eliminated, the structural strength is maintained over much longer periods. Chimneys and ducting are made in sections up to 15ft long which are usually joined by means of flanges on the inner and outer skins, both flanges projecting externally and being insulated one from the other to avoid local heat losses. These flanges are welded in position and form a rigid bolted connection. Differential expansion between the two tubes is taken up in the design of the inner flange, which permits the inner skin to expand without undue stress being set up. Welded or socketed connections can also be arranged without difficulty, and also branches and bends in the same way as ordinary mild steel chimney or ducting construction. Attachments for stays, brackets, &c., can be welded or clamped to the outer surface without impairing the efficiency of the installation.

The insulation comprises corrugated aluminium foil which is inserted into the ⅝in air gap between the inner and outer walls during construction. The highly reflective surface of this insulation reduces radiation losses to a negligible amount. The interior surfaces of the mild steel skins are also sprayed with heat resisting aluminium paint to further reduce heat loss and the outside of the chimneys are given a coat of protective aluminium paint.

Convection losses are minimised by dividing the annular space between the skins longitudinally into sections not more than 2ft long with fibrous insulation which restricts circulation in the air gap. Still air, being a good heat insulator, ensures that conduction losses are small due to the double skin construction, and the temperature gradient through the composite wall is such that the inner skin is maintained at the highest possible temperature relative to the flue gas. The makers point out that this form of construction can equally well be used for rectangular or square ducting with similar beneficial results. A series of tests quoted by the makers, and which were carried out on a chimney by the British Petroleum Company's research centre, showed that the inner skin temperatures of a " Dribore " chimney were maintained consistently above those at which severe corrosion would take place.

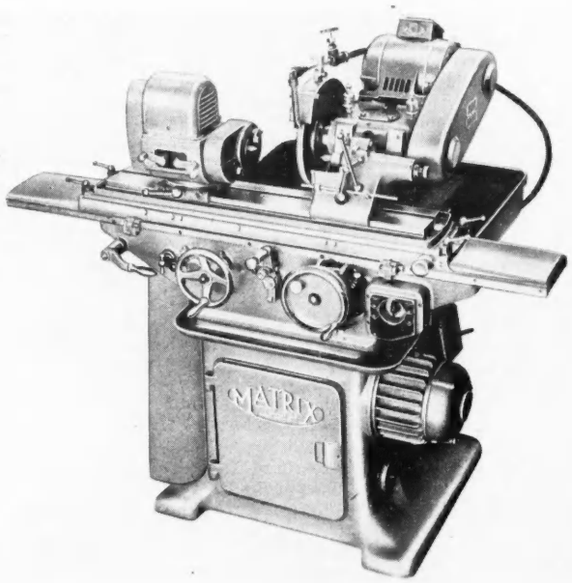
[Reply Card No. E3222]

Precision Cylindrical Grinding Machine

A PRECISION cylindrical grinding machine with a self-contained motorised workhead for live- and dead-centre work, now made by the Coventry Gauge and Tool Company, Coventry, takes 24in between centres and swings up to 8¼in over the table. The workhead, driven by a ⅓ h.p. motor, incorporates a gearbox providing six spindle speeds of 60 to 600 r.p.m. The spindle, mounted in precision taper roller bearings, has a threaded nose for chucks, faceplates, &c., and a draw-in collet attachment with a maximum collet capacity of ⅝in diameter is available. The workhead can be swivelled to any required angle. The tailstock casting houses a spring-loaded barrel provided with adjustment for centre pressure, and a dressing diamond holder mounted above the centre enables the wheel to be dressed without disturbing the workpiece.

The table is driven by a 1 h.p. motor, there being twenty-four table speeds, from 4in to 120in per minute. For taper work the upper table can be swivelled up to 20 deg. included angle with fine adjustment by micrometer screw. A scale indicating taper per foot is fitted.

The wheelhead is powered by a 1½ h.p. motor,



Cylindrical grinder with motorised workhead for live and dead-centre work and taking up to 24in between centres and swinging up to 8¼in over the table

from which the drive is transmitted to the spindle by vee belts, three spindle speeds being available through interchangeable pulleys. The spindle runs in adjustable plain bearings and a 12in diameter by 1in wide wheel is fitted as standard; the maximum peripheral speed being 6000ft per minute. Wheel infeed is by a precision leadscrew and nut operated by a handwheel fitted with a large diameter calibrated dial. Fine increments of infeed are applied by depressing a lever which turns the leadscrew through a ratchet and pawl mechanism. The machines can be fitted with a universal wheelhead having a compound swivel and independent top slide movement which enables the wheel to be fed into the work at any angle to the table axis. The wheel can be rapidly advanced or withdrawn by a quick action lever and an adjustable stop ensures accurate repeating. The internal grinding attachment available is mounted on an accurately machined locating face on the wheelhead casting, and has a spindle speed of 22,000 r.p.m.

[Reply Card No. E3223]

Data Monitoring and Display

A TABULATED numerical record of slowly-varying quantities in an industrial plant can be obtained by means of a data monitoring and display system developed by the Computer Department of Redifon, Ltd., Gatwick Road, Crawley, Sussex. The system is designed to measure, display and record voltages obtained from transducers distributed about a plant for the monitoring of physical variables such as pressure and flow. Measured voltages are displayed in digital form as a row of illuminated numerals, and can also be recorded on a paper roll by a digital print-out equipment. If the voltages are varying on a convenient time scale they can be displayed on a 5½in cathode-ray tube which is an integral part of the equipment. For slower-varying voltages a multi-channel pen recorder or " Skiatron " form of display can be provided. The range of voltage measurement is 0–199·9V, positive or negative, to an accuracy of ±0·1 per cent, while the cathode-ray tube timebase has seven speeds ranging from five sweeps per second to twenty sweeps per hour (it can also be operated on a single-shot basis).

Selection of the sources to be measured can be either manual, by a rotary switch, or automatic, by a scanning system using electromechanical rotary selectors. With this automatic scanning system forty-eight sources can be scanned in approximately two minutes, and the system can be expanded in multiples of forty-eight. The mechanism can be stopped on any position during the scan and can be returned to zero by a switch. As each reading is made, the " station " or source identification code number is automatically indicated on the control panel and printed out. In the accompanying illustration the four windows of the digital voltmeter are seen on the main unit panel, and above them the two windows of the source identification display.

The electronic design of the digital voltmeter is based on comparison of the voltage under measurement with standard reference voltages in three decades. Since the most significant figure must be either 0 or 1 (the maximum voltage that can be measured being 199·9), a ten-division decade is not required for determining this condition. Consequently, the next most significant figure is established in the first of the three decades, the next most significant in the second decade, and so on. The reference voltages are derived by means of potential dividers from an external 50V supply having an accuracy of ±10mV. This same 50V supply, not a proportion of it, is used in all the decades ; d.c. drift-corrected amplifiers, each with a gain of ten, are connected between the decades to make this possible. For example, if a voltage of 34·2V is being measured, the first decade detects and indicates correspondence with the reference 30V. The input of 34·2V is applied also to the next decade through a d.c. amplifier, but before it is amplified the initial 30V reference is subtracted from it (by an analogue computing technique). Thus the amplifier in fact amplifies 4·2V to give an output of 42V, which is compared with the reference voltages in the second decade. Here, correspondence with the 40V reference is detected and indicated. Then in the last d.c. amplifier this 40V reference is subtracted from 42V, so that a 2V input is amplified to give 20V output for the comparison in the third decade.

The scale of all input voltages may be varied individually by the optional inclusion of a d.c. amplifier in each channel. If this facility is included a limiter may be associated with each amplifier to operate a relay when an input reaches a preset level, the relay signals being used for warning or control.

[Reply Card No. E3231]

Electronic Level Measurement

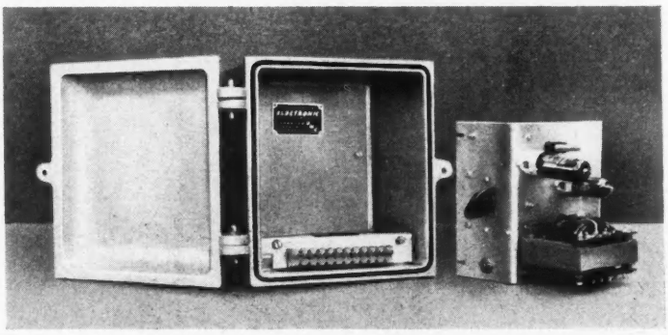
CONTINUOUS indication of the level of contents in tanks, silos, hoppers and similar containers is given by the " Contimitor " instrument illustrated, a product of the Electronic Machine Company, Ltd., Mayday Road, Thornton Heath, Surrey. Monitoring is effected by a capacitive system in which a probe or transducer is connected in the signal grid circuit of a triode-hexode valve. The triode (oscillator) section of the valve is crystal-controlled, and the variations in output reflecting changes in level occur in the current through the hexode portion as a result of the " pulling " effect when alterations in the hexode signal grid circuit capacity vary the relative phase of the signals in the two portions of the valve. A capacity change of 10 picafarads will give a reading over a range of nil to full-scale on a 1mA meter, or a negative-giving voltage change of 5V relative to earth may be derived, enabling a d.c. amplifier to be driven. Where extreme sensitivity is required, provision can be made for a 1mA change of output for a capacity variation of 0·03 picafarad. In installations where high minimum values of capacity are encountered, with relatively large changes in capacity as the level rises, adjustment can be made by tapping down the coil at the probe end of the circuit. A matched transmission line connects the instrument to its probe or transducer, and cable lengths of up to 100 yards can be used without loss of stability, the line being unaffected by the presence of metal girders and the like along its run.

The cast aluminium case of the " Contimitor " is designed for heavy industrial use, and the electronic chassis can be withdrawn completely, as seen in the illustration, by loosening four screws, leaving the installation wiring undisturbed. Typical applications suggested for the instrument are continuous level monitoring or control of fluids and solids in tanks or hoppers, foam detection, vibration detection and measurement, machine control, or as a safety device on other machines. It is also applicable to measuring the thickness of paper or plastics, or to certain counting problems where random displacement of the objects being counted occurs.

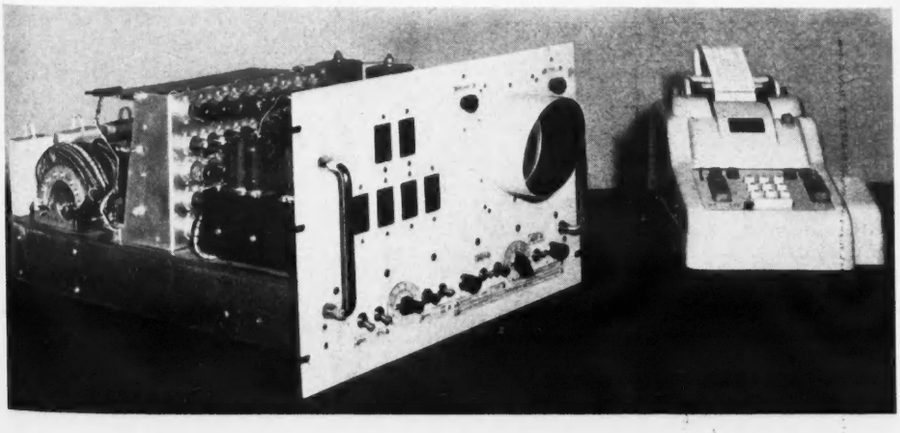
[Reply Card No. E3232]

Integrator for Chart Recorders

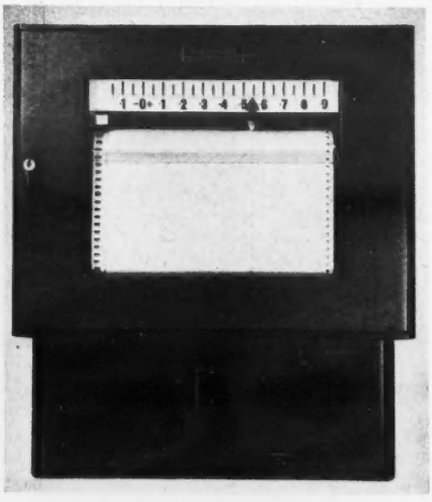
AN attachment for a strip chart recorder which records and displays the integral of variables under measurement has been introduced by Honeywell Controls, Ltd., Ruislip Road East, Greenford, Middlesex. We illustrate the device attached beneath a Honeywell " ElectroniK " strip chart recorder. The integral is obtained by counting known areas enclosed by the curve and the total is presented as a permanent record on the left of the chart simultaneously with the tracing of the curve showing instantaneous values. It appears in the form of two series strokes, one recording each count and the other recording each tenth count. At the same time the integral is shown on a four-digit counter on the front panel of the integrator. The counter is operated by pulses derived from a photodiode energised from a light beam. The beam is interrupted by a slotted disc driven from a gearbox which provides four different chart speeds. Solenoids connected to the units and tens displays of the digital counter control the integration pen on the recording chart. The pulses from the photodiode may also be fed to data handling apparatus or remote counting equipment. Typical applications of the equipment include gas chromatography, flow measurements, and measurements of electric power consumption.



Electronic chassis of capacitive level monitor removed from case



Main unit, with digital voltmeter and print-out equipment of data monitoring system



Strip chart electronic recorder with integrator

[Reply Card No. E3233]

INDUSTRIAL NEWS

Iron and Steel

Steel production in Great Britain in July, a month during which several works were closed for summer holidays, dropped considerably to an average of 391,400 tons a week compared with 466,400 tons a week in June. It was still, however, well above the weekly average of 320,300 tons for July last year. Pig iron production during July was at an average of 288,900 tons a week compared with 295,200 tons a week in June and with 221,600 tons a week in July, 1959.

Deliveries of finished steel to home industries during the second quarter of this year are estimated to have been 3,007,000 tons. Preliminary results of the census of consumers' stocks of steel taken at the end of June this year suggest, states the Iron and Steel Board, that stocks rose during the second quarter of the year by a little over 8 per cent or by some 270,000 tons of finished steel. This is the largest recorded quarterly increase in stock and approaches in magnitude the fall of 310,000 tons recorded in the fourth quarter of 1958. The increase in sheet stocks in the second quarter of 1960 accounts for about a third of the total rise.

Provisional figures issued by the Board show that deliveries of finished steel to the constructional engineering and building industries during the second quarter of 1960 amounted to 423,000 tons compared with 300,000 tons in the corresponding quarter last year, delivery to the wire industry was 252,000 tons in the second quarter of 1960 as against 171,000 tons in the second quarter of 1959. The only main steel-using industry recorded as taking less finished steel in the second quarter of 1960 than in the second quarter of 1959 was shipbuilding, where the figure was 122,000 tons compared with 127,000 tons.

The Iron and Steel Board has assessed the home usage of steel in the second quarter of 1960 at 3,851,000 tons, compared with 3,798,000 tons in the first quarter. On a seasonally-corrected basis, usage in the second quarter was about 2½ per cent above the first quarter.

Railway Pay Agreement

A joint review of the effect of the recent changes in the salaries and wages structure of British Railways salaried and conciliation staff upon comparable staff of London Transport has been completed. London Transport and the three railway unions, the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen and the Transport Salaried Staffs' Association announce that agreement has now been reached under which the rates of pay of London Transport staff concerned have been aligned as closely as practicable with those of British Railways for comparable work. The revised rates of pay arising from the review are to apply from January 4, 1960, states London Transport, as in the case of British Railways.

In carrying out this review, London Transport points out, regard was had to the principles established by the independent decision in 1955 of a wages board under the chairmanship of Lord Terrington, covering London Transport's railway staff, which decided that in arriving at the rate for the job on London Transport railways, regard must be had to the rates agreed as appropriate for workers engaged on similar duties on the main line railways.

Mines and Quarries

The Ministry of Power has published the report of H.M. Chief Inspector of Mines and Quarries for 1959. In his report the Chief Inspector says that, but for the disaster at Auchengeich Colliery in September in which forty-seven men were killed, the number of fatal accidents in coal-mines in 1959 would have shown a decline very much in line with the reduction in the number of manshifts worked. The number of men killed in accidents in coal-mines during the year was 348 compared with 327 in 1958. The experience of the last few years suggests that, disasters apart, there is still a trend towards lower accident rates, but that it is now appreciably slower than in the 1940s and early 1950s. The rate of improvement was bound to lessen, the report adds, but the failure to make better progress in the last seven years cannot be accepted with equanimity. On average, the report points out, there is still more than one fatal accident every working day. The number of serious non-fatal accidents during the year was 1676 compared with 1752 in 1958.

During the year under review 3 people were killed and 8 seriously injured in mines of stratified ironstone, shale and fireclay ; 4 people were killed and 20 seriously injured in other mines, whilst in quarries, 30 people were killed and 94 seriously injured.

At the end of the year 1355 coal-mines were being worked, states the report, 875 by the National Coal Board and the remainder by private owners under licence from the Board. H.M. inspectors made 25,083 inspections during the year, 16,027 underground and 9056 on the surface. Six hundred and eleven mines were inspected throughout.

Steel Industry Expenditure

Capital expenditure by the steel industry last year was close on £100 million it is stated in a survey published in the British Iron and Steel Federation's July issue of *Steel Review*, and it is estimated that expenditure in 1960 will rise to a new record of about £125 million and may reach £150 million, or more, in 1961 as the accelerated strip mill programme gets into its stride. The prospect of this heavy expenditure, says the *Steel Review*, emphasises the vital importance of adequate sources of finance. The new strip mill projects of Colvilles, Ltd., and Richard Thomas and Baldwins, Ltd., are able to call upon Government loans, but these were special arrangements dictated by the difficult conditions obtaining before the General Election. Now that the threat of re-nationalisation has receded there are good reasons for supposing, the survey suggests, that companies will in future be able to turn to the capital market for support as, indeed, Stewarts and Lloyds has already done successfully with a rights issue of £14,000,000 in November, 1959.

The production of crude steel in the first half of this year was 28 per cent higher than in the corresponding period last year and has been running up against the limits of existing capacity. The output of iron and steel in each successive month this year has been the highest recorded in that month in any year. Current production is broadly in line with expectations, the survey says, and the 1960 forecast of 24,000,000 tons of crude steel seems likely to be achieved in spite of signs of easier demand in some sectors.

Education for Industry

The Central Advisory Council for Education (England), under the chairmanship of Sir Geoffrey Crowther, published in December, 1959, its report on the development of education for young people aged fifteen to eighteen, and the Minister of Education then said that he wished to have the views of industry and others interested in this matter on the recommendations made in that report. The report has since been the subject of a study by the British Employers Confederation's Industrial Education and Training Committee, with the help of a special sub-committee which it set up for the purpose. The report of the committee has now been published as a supplement to the current issue of the Confederation's *Bulletin*.

The Confederation's Committee considers that the advantage to industry of better educated recruits which would result from an additional year of full-time education would outweigh any disadvantages, and it accordingly supports in principle the raising of the school leaving age to sixteen. It agrees with the Minister of Education, however, that the extra year's full-time education should not necessarily be spent in school but would, in the case of some young people, be better spent in a technical college. This, the committee thinks, would link in naturally with the recommended period of further education up to the age of eighteen, which is provided for in the 1944 Education Act. The committee goes on to suggest that it is unnecessary to decide a national priority between the raising of the school leaving age and the establishment of "county colleges," but rather that freedom should be given to each local education authority to develop in the way that suits it best without having to conform to a rigid national pattern. In line with this thinking, states the report, the committee sees no reason for the introduction of yet another category of further educational establishment, and that therefore "county colleges" should be regarded as colleges of further education in the broadest sense.

A sample survey referred to in the Crowther Report indicates that over two-fifths of the ablest boys—the top 10 per cent in ability—leave grammar school by the age of sixteen. The need for schools to be more informed on the careers opportunities for young people other than those available after a university degree is accordingly urged in the report — for example, those for which National Certificate, City and Guilds or equivalent qualifications are appropriate—so that they may adjust their curricula to meet the needs of these young people. The curricula should not, however, be so radically changed as to include subjects specifically related to industry and commerce, the report adds.

PERSONAL AND BUSINESS

Appointments

MR. E. B. THAIN has been appointed manager of Yates Plant, Ltd.

MR. V. C. PRICE has been appointed a director of Sandvik Steel Band Conveyors, Ltd.

MR. ERIC NEWBIGGINS has joined Stanley Works (G.B.), Ltd., as sales promotion manager.

MR. D. F. HAYDON has been appointed general sales manager of Baird and Tatlock (London), Ltd.

MR. F. HOLMES has been appointed technical marketing manager for the Westrex Company, Ltd.

MR. DOUGLAS E. GRAHAM has been elected chairman of the Council of the Institute of Export for the year 1960-61.

MR. D. J. BICKLEY, A.M.I.Mech.E., has been appointed technical sales manger of the Globe Pneumatic Engineering Company, Ltd.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces the appointment of Mr. P. M. Hollingsworth, M.I.E.E., as assistant chief engineer.

MR. JOHN H. D. PEARCE, formerly sales manager of Dartmouth Auto Castings, Ltd., has been appointed to the board of the company as sales director.

THE INSTITUTE OF SHEET METAL ENGINEERING announces that Mr. Allen E. Gilbert has been elected as chairman of the council in succession to Mr. F. B. Hooper.

THE FEDERAL POWER BOARD OF RHODESIA AND NYASALAND announces the appointment, with effect from October 1, 1960, of Mr. G. R. Peterson, M.I.E.E., M.I.Mech.E., as general manager.

MR. FREDERICK BAILLIE has joined the Cambridge Instrument Company, Ltd., as production manager, and is responsible for all aspects of production planning at the company's three factories in the United Kingdom.

THE MINISTRY OF AVIATION has announced the appointment of Air Vice-Marshal T. U. C. Shirley, M.I.E.E., F.R.Ae.S., to be deputy controller of electronics in succession to Air Vice-Marshal G. P. Chamberlain, who is retiring from the Royal Air Force.

BROWN BROTHERS AND CO., Ltd., announces that Admiral Sir Michael Denny has been appointed chairman of the company in succession to Mr. Iain M. Stewart, M.I.Mech.E., M.I.N.A., M.I.Mar.E., who has resigned from the chairmanship for domestic reasons.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., TRACTION DIVISION, announces the appointments of Mr. J. H. Cansdale, M.I.E.E., M.I.Loco.E., sales manager; Mr. J. C. Way, A.M.I.E.E., A.M.I.Loco.E., deputy sales manager; and Mr. J. Rostron, M.I.Loco.E., assistant sales manager.

ATLAS COPCO (GREAT BRITAIN), Ltd., announces the following appointments: Mr. A. Hayes, chief sales engineer for mining products in Great Britain; Mr. W. T. Jones, manager, mining division; Mr. R. Marshall, technical representative; Mr. Ralph Norén, manager for stationary compresser sales.

NEWTON CHAMBERS AND CO., Ltd., announces that Mr. K. E. Walker, director in charge of the engineering division of Newton Chambers, has been appointed chairman of its subsidiary company Rhodes and Halmshaw, Ltd. Mr. Frank Whitehouse, general works manager of Newton Chambers engineering division, has also been appointed a director of Rhodes and Halmshaw. Mr. R. J. V. Wheeler, secretary of Newton Chambers, has been appointed secretary of the subsidiary company.

BRITISH AIRCRAFT CORPORATION, Ltd., announces the following appointments: Mr. Allen H. C. Greenwood, A.F.R.Ae.S., is to co-ordinate aircraft sales and service within the Group; Mr. G. R. Bryce is to be chief test pilot of the Corporation, and W. C. R. P. Beamont becomes deputy chief test pilot. Consequent upon Mr. Bryce's appointment, Mr. E. B. Trubshaw has been appointed chief test pilot of Vickers-Armstrongs (Aircraft), Ltd., and Mr. M. J. Lithgow becomes deputy chief test pilot.

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY announces the following senior appointments at the Atomic Energy Research Establishment, Harwell: Dr. F. A. Vick, at present deputy director of the Establishment, has been appointed director; Dr. R. Spence, at present chief chemist, has been appointed deputy director, and Mr. L. Grainger, now head of the metallurgy division, has been appointed assistant director, with special responsibilities for applied research. The new appointments will take effect on September 1.

Business Announcements

THE UDAL GROUP OF COMPANIES has taken over new factory premises at Beeston, Notts., and has named them Pountney Works.

ROWNSONS (CONVEYORS) Ltd., Maiden Lane, York Way, London, N.7, states that its name has been changed to Rownson Conveyors, Ltd.

MARTONAIR, Ltd., announces that its Scottish office and stock room has been moved to 128, Nithsdale Road, Glasgow, S.1 (telephone, Pollock 3929).

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that the address of its Reading branch is now Katesgrove Lane, Reading (telephone, Reading 55074).

F. R. BULLEN AND PARTNERS state that their Darlington office and laboratories are now at 129, Victoria Road, Darlington, Co. Durham (telephone, Darlington 66391).

JOHN DOSSER AND ASSOCIATES announce that the senior engineering assistant, Mr. Kenneth Wesley Whimster, M.I.C.E., has been taken into partnership. The name of the firm remains unchanged.

CAIRD AND RAYNER, Ltd., 777, Commercial Road, London, E.14, announces that it has acquired the patents, trade marks, and manufacturing rights of the Turn-Over Filter Company, of Prince Regent Road, Belfast.

THE WEAN ENGINEERING COMPANY INC., of Warren, Ohio, has established a new company in Great Britain—Wean-Miles, Ltd., 76, Cannon Street, London, E.C.4—to furnish strip and tin mill equipment of Wean design.

SIR LESLIE GAMAGE, chairman and managing director of The General Electric Company Ltd., is to retire at the end of this year. He will relinquish his executive duties as managing director immediately, but will continue as chairman until December 31.

STRACHAN AND HENSHAW, Ltd., Steelhoist Works, St. Philips, Bristol, 2, has opened a London office at Room 351, Victoria House, Southampton Row, W.C.1. (telephone, Chancery 2250). Mr. P. A. Denning has been appointed as manager of the office.

ASSOCIATED ELECTRICAL INDUSTRIES (RUGBY), Ltd., states that its Midland regional office in Birmingham has moved from John Bright Street and Hospital Street to Gloucester House, 65, Smallbrook, Ringway, Birmingham, 5 (telephone, Midland 6335 and 9551).

I.G.E. (CONTROL EQUIPMENT), Ltd., is the new name for Industrial Guarding Equipment, Ltd. The change follows concentration by I.G.E. on automation and semi-automation control devices. The company's address is Interlock Works, Court Road, Birmingham, 12.

DR. J. C. HUDSON, who has been in charge of the British Iron and Steel Research Association's research on corrosion for the last fifteen years, is to retire at the end of August. He has, however, agreed to act as consultant to the Corrosion Advice Bureau and the Chemistry Department.

D. A. STUART OIL COMPANY (G.B.), Ltd., 11a, Albemarle Street, London, W.1, is a new company formed as a wholly-owned subsidiary of the Amber Group of Companies to market in this country the products of D. A. Stuart Oil Company, Ltd., of Chicago and Toronto. Sales director of the new company is Mr. R. F. Middleton.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., and Davy-United, Ltd., have announced the formation of a jointly-financed steel works automation unit to apply new automatic control techniques to the processing both of steel and of non-ferrous metals. The A.E.I./Davy United Steelworks Automation Unit has its headquarters at Mill Road, Rugby.

SIMON-CARVES, Ltd., and MONSANTO CHEMICALS, Ltd., have pooled their research, engineering and operating experience in the treatment and harmless disposal of industrial effluent to form the Simon-Carves Monsanto Effluent Advisory Service. The service is administered by Simon-Carves, Ltd., from its headquarters at Cheadle Heath, Stockport, Cheshire.

THE DRAYTON REGULATOR AND INSTRUMENT COMPANY, Ltd., states that it has obtained an additional 55,000 square feet of factory space in West Drayton. Following the removal of S. C. Johnson and Son, Ltd., to its new establishment at Frimley Green, Surrey, the Drayton Regulator and Instrument Company, Ltd., will take over its Bridge Works towards the end of the year.

Contracts

FERRANTI, Ltd., has received an order from the Norwich Union for an "Orion" data processing system. The equipment, involving a total cost of over £250,000, will be installed in the Society's new head office building now being erected in Norwich.

STONE-WALLWORK, Ltd., Stone-Platt Group, has secured a contract worth over £100,000 for the supply of foundry equipment to Czechoslovakia. The equipment includes automatic moulding, core making and shakeout machinery, to be installed in new tractor and automobile foundries in 1961 and 1962.

MULLARD, Ltd., has been awarded a contract valued at 2,000,000 dollars for the supply of travelling wave tubes to the Radio Corporation of America for use in a new R.C.A. multi-channel radio communication system to be manufactured by the Radio Corporation of America. The tubes were developed by the Mullard Research Laboratories and will be manufactured at the company's transmitting and microwave valve plant at Waddon, Surrey. First shipments are expected to be made in May, 1961.

RICHARD COSTAIN (AFRICA), Ltd., has been awarded a £410,000 contract in connection with the Walker's Ferry Scheme, Nyasaland. The contract is being carried out for the Mudi River Water Board, the consulting engineers being Scott and Wilson, Kirkpatrick and Partners. It entails laying 30 miles of high pressure main varying from 24in to 12in diameter, including several river, road and railway crossings, between the Shire River and Blantyre/Limbe. The scheduled time for completion of the contract is two years.

PELAPONE, Ltd., of Derby, a member of the Steel Group of Companies, has been awarded the contract for the supply and installation of all functional electrical equipment for the new Trinity House lighthouse at Dungeness, Kent. The company will be responsible for the power supplies and manufacture, to designs and specifications prepared by the Engineer in Chief's Department, Trinity House, of all the control gear for the light and fog signal. The complete electrical and mechanical services, including installation commissioning and handing over to Trinity House, are being undertaken by Pelapone as manufacturing consultants.

THE WESTINGHOUSE BRAKE AND SIGNAL COMPANY, Ltd., has received an order from Murgatroyd's Salt and Chemical Company, Ltd., for a silicon rectifier equipment which, with a rating of 50,000A at 200V, is considered to be probably the largest made in Britain. This equipment will be used for the production of chlorine and caustic soda by the electrolysis of brine derived from underground salt beds. The silicon rectifier diodes will be mounted on water-cooled busbars in four separate cubicles. The transformers stepping down from 11kV, and the tap-changing equipment and bridging regulators to provide continuity of current control, are being supplied by The General Electric Company, Ltd.

JOHN HOWARD AND CO., Ltd., has started work on a contract stated to cost "more than £695,000" on a road and bridge scheme linking North Wales and the industrial North of England. The bridge will replace the Queensferry bridge over the River Dee near the eastern border of Flintshire and the new road will divert traffic from the village of Queensferry. The new bridge will take two 24ft carriageways over the Dee, about 200 yards upstream from the existing bridge, and will be open to traffic in about a year's time. The consulting engineers for the bridge are Messrs. Mott, Hay and Anderson, and the scheme has been prepared and is being supervised by Flintshire County Council (County Surveyor, Mr. E. W. W. Richards, M.I.C.E.).

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., Heavy Plant Division, has received an order worth about £700,000 for electrical equipment for a new rod mill for the Broken Hill Proprietary Company, Ltd., Australia. The mill will be driven by d.c. motors ranging in output from 600 h.p. to 2500 h.p., and the total power available will be 17,700 h.p. Mercury-arc rectifiers, total rating 13,000kV, will supply the mill motors. Switchgear, control gear, auxiliary drives, and other equipment are included in the order. Most of the electric control equipment required will be manufactured in Australia by Australian Electrical Industries (Proprietary), Ltd. Responsibility for manufacturing the rest of the equipment will be shared by the Rugby and Manchester (Trafford Park) works of A.E.I.

CONTINENTAL AFFAIRS

by Our Continental Editor

Vianden Pumped Storage Scheme

A major hydro-electric pumped storage plant has been under construction since July, 1959, near Vianden in Luxembourg. The station will supply peak energy by means of a daily cycle of eight hours' pumping and four-and-a-quarter hours' generation, making use of the water of the river Our of which about 10 hm³ (N.B. 1 hm=1 cubic hectometre=1,000,000 cubic metres) are to be impounded in a reservoir extending for about 8 km along the valley. A volume of nominally 4·84 hm³ will circulate between this and the 6 hm³ upper reservoir sited on a nearby hilltop which rises nearly 300m above the valley. Of the total installed generating capacity of 800MW, and the 552MW pumping capacity, one half will be in commission by the autumn of 1962. Annual generation will then amount to 600GWh and this can subsequently be doubled. Overall cycle efficiency is expected to exceed 70 per cent.

DURING recent years, the increasing power demands of the western European grid systems, in particular the demand for peak power, has led to the development of long-distance transmission from hydro-electric stations in the Alps to the industrial regions of north-western Europe.

These industrial centres, having sprung up in the first instance because of the presence of coal, and being in many cases also accessible by water, nowadays form important focal points for the generation of thermal power from local or imported coal or from oil. Since thermal stations operate best on base-load, it is very convenient to incorporate in the same grid a proportion of hydro-electric stations which not only supplement the basic capacity but, in addition, are useful sources of peak power.

Although hydro-electric storage schemes have these advantages, their capital cost is high and the remaining exploitable resources are not unlimited.

Additional hydro-electric peak power may, however, be supplied by using pumped storage.

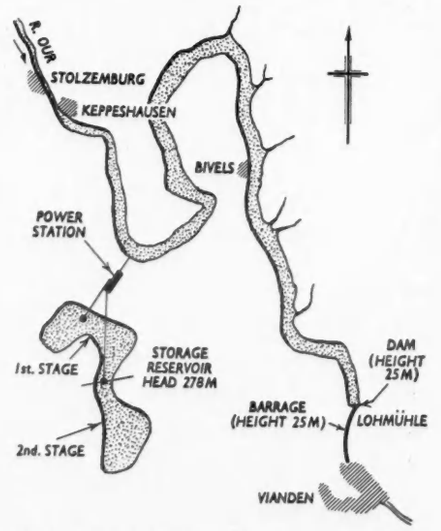


Fig. 1—General layout of Vianden pumped storage scheme

Pumped storage stations do not depend upon the presence of a large run-off and a topology which makes it feasible to impound the water at not too great a cost. All that must be present is the possibility of constructing two reasonably large storage basins at two widely differing levels and of keeping them filled from some small or medium-size river. Off-peak power from thermal or run-of-river generating stations is used to pump water from the lower into the upper reservoir. The water stored in this way is then used to supply peak power to the grid. An overall efficiency in excess of 65 per cent is considered quite feasible. Important examples of this type of power station on the Continent are Lünersee* and Glockner Kaprun† in Austria. In Germany, over twenty such schemes have been built or are projected, including Happurg Reisach-Rabenleite and Geesthacht near Hamburg,‡ the last-mentioned designed for six 35MW pump sets and having a reservoir of 3hm³ capacity. In this country, pumped storage stations are under construction at Ffestiniog (300MW generating capacity) in connection with Trawsfynydd nuclear power station (500MW electrical) and at Awe (400MW generating capacity) in connection with Hunterston nuclear station (300MW electrical net output).

Particularly advantageous conditions for installing pumped storage are to be found along the north-eastern part of the Luxembourg-German border which is formed by the river Our. This river is a tributary of the Sauer (Sûre) which flows into the Moselle at a point about 10km upstream from Trier.

North of Vianden the Our winds its way between hills into which it has cut a 250m to 300m deep valley. Already in 1925, a scheme had been proposed to convert the whole of the valley into a reservoir of 800 hm³, by constructing a dam 106m high. This project was never carried out, partly because of political obstacles.

In 1951, the Grand Ducal Government set up the Société Electrique de l'Our (SEO) with the task of planning, building and operating the Our power station. The capital of SEO is held to the extent of 40 per cent by the Grand Duchy of Luxembourg, 40 per cent by the Rheinisch-Westfälisches Elektrizitätswerk A.G., Essen, 10 per cent by other companies, and 10 per cent by private citizens of Luxembourg.

* THE ENGINEER, August 16, 1957, page 240.
† THE ENGINEER, September 14, 1956, page 379; September 21, page 417; September 28, page 453.
‡ THE ENGINEER, February 15, 1957, page 543.

In September, 1954, SEO published its proposals for constructing a pumped storage scheme with an installed generating capacity of 640MW and an annual output of 870GWh. These figures have since been raised to 800MW and 1200GWh, respectively. An overall efficiency exceeding 70 per cent is envisaged. The scheme (Fig. 1)

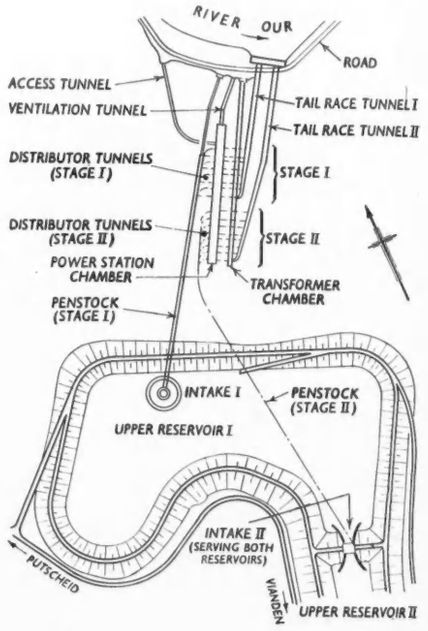


Fig. 2—Detail layout showing Vianden power station and upper storage reservoirs

comprises a lower reservoir of 9·5 hm³ total and 5·5 hm³ useful capacity formed by a dam across the valley at Lohmüle, a short distance upstream from Vianden, and extending back as far as Stolzembourg. An upper reservoir of 5·5 hm³ useful capacity is to be provided on the top of the Nikolausberg mountain, near the village of Bivels and on the right (Luxembourg) bank of the river. The two reservoirs are to be connected to an underground generating and pumping station housing a total of eight sets which will operate under a gross head of water of 267m to 290m.

The decision to build was taken on July 23, 1959, and work at the site started three weeks later. The project is being carried out in two stages, of which the first, due for completion in the autumn of 1962, comprises the lower basin to its full extent, the whole of the underground power-house, intakes, penstocks, and discharge tunnels, one-half of the upper basin, and one-half

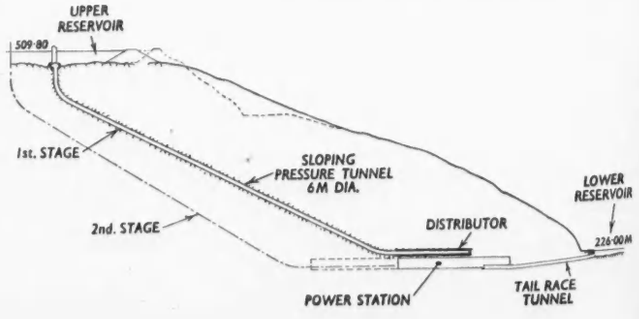


Fig. 3—Sectional elevation

the number of sets, representing a generating capacity of 400MW. The scheme can then be completed later on simply by adding the second half of the upper storage basin and installing the remainder of the sets.

Lower Reservoir

About 1 km upstream from the little town of Vianden, the river Our is being impounded by means of a gravity dam at Lohmühle, the site of an ancient mill. This dam, the foundations of which are now being constructed, will have a crest of about 150m at 228·5m sea level, and a concrete volume of about 40,000 cubic metres. The dam will be provided with four scour culverts and a spillway with sill at 223m sea level. A small power station will be installed to serve the needs of the plant.

The river bed here is at 202m sea level, and it is envisaged to impound the water to 227m sea level, thus forming a reservoir extending some 8 km upstream, i.e. nearly as far as Stolzembourg. The total volume of water impounded will amount to 10 hm³ of which 6 hm³ represent useful capacity, i.e. the amount which will be pumped into the upper reservoir and drained down through the turbines in a daily cycle. The useful reservoir volume represents a sheet of water 7·25m thick, so that the lower reservoir level will be at about 220m sea level, or 18m above the river bed. The 4 hm³ of "dead" volume thus retained are necessary in order to keep most of the flat valley bottom under water at all stages of the pumping cycle, and so prevent the formation of mud flats which would spoil the amenities of the district.

Ancillary work.—Part of the village of Bivels will be flooded and a section of the valley road at Lohmühle has to be transferred from the right bank to the left. This involves bridging the Our in two places. The bridge spans consist of prestressed compound girders overlaid with prefabricated deck slabs. The girders, made by the Preflex Company, Brussels, consist of rolled steel "I"-sections which have concrete compression flanges cast on, while being deflected by jacks into a slight arch shape. The jacks are released when the concrete has hardened, thereby maintaining a precompression in the tension flange of the girder. One of the bridges is carried on piers which were continuously cast in concrete with the help of climbing shuttering.

Upper Reservoir

The upper reservoir (Figs. 2 and 6) is being constructed on the flat summit of the Nikolausberg mountain (Mt. Saint-Nicolas) near Bivels. This hill, which is slightly higher than its neighbours on either side along the river, rises about 300m above the valley bottom, from which its horizontal distance is about ½ km.

In accordance with the plan to develop the power station in two equal stages, half the upper reservoir is now under construction. The remainder can be completed at a later date by simply extending the earth dam to enclose a further area of hilltop. In its final state the reservoir will consist of two independent crescent-shaped basins roughly in the shape of a figure "3." Basin I contains the intake for the four tubine-pump sets of the first stage, while a second intake suitable for either basin will be constructed in the short dividing dam at the waist of the "3."

The crown length for Stage I will be about 2·3 km and the total length for both stages 4·3 km. A useful volume of 2·75 hm³ will be impounded in each half basin, the sheet of water being 16m thick. Maximum water level will be at 509m sea level.

The dam section is trapezoidal with an inside slope of 1 in 1·75 and an outside slope of 1 in 1·5. The crown at 511·3m sea level is 4m wide. Actual height above the terrain varies according

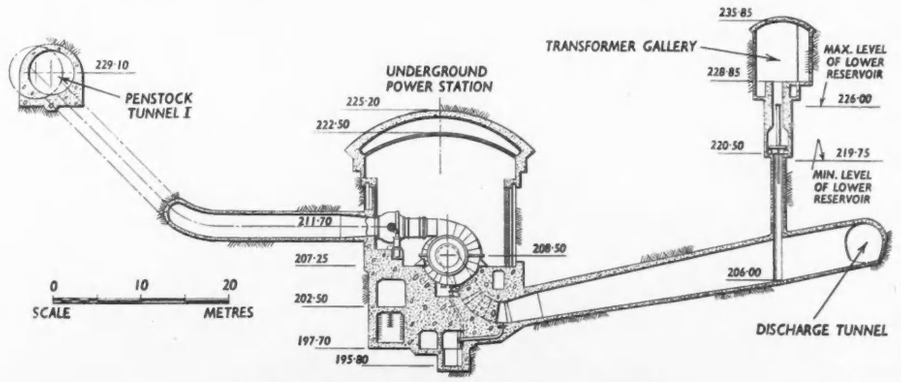


Fig. 5—Sectional end view through power station

Fig. 6—Aerial view of Stage I upper reservoir under construction on Mt. Saint-Nicolas. The Our valley is in the background

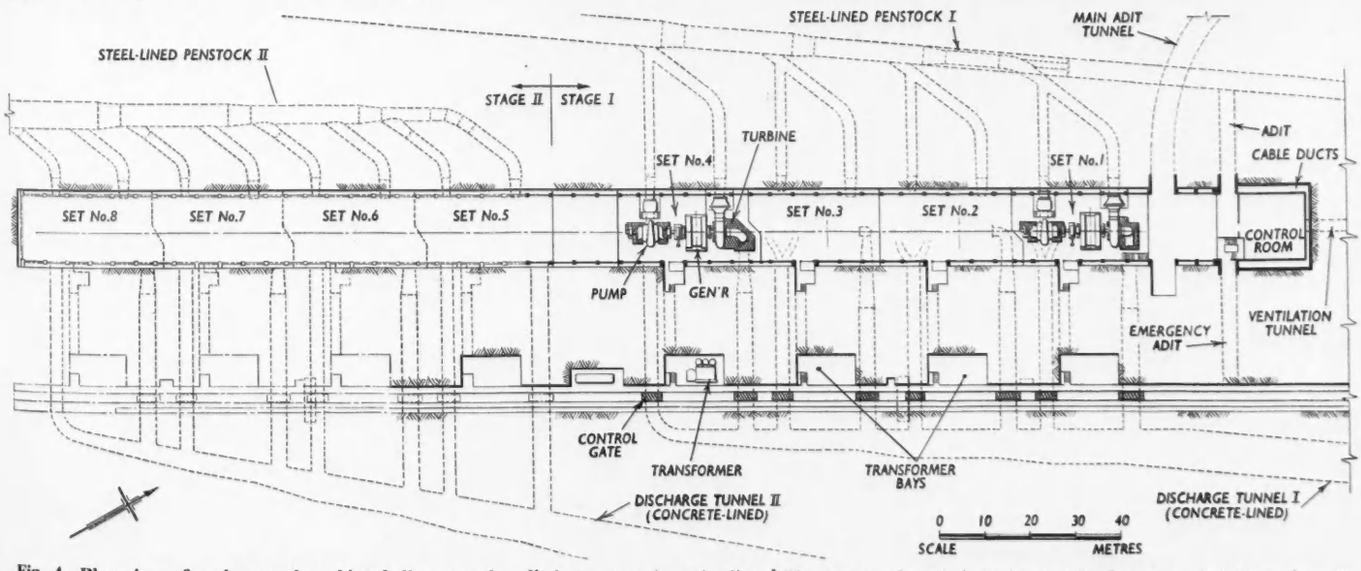


Fig. 4—Plan view of underground machine hall, penstocks, discharge tunnels and adits. The structural work is to be completed *in toto*, but the equipment for Stage II will be installed at a later date

CONTINENTAL AFFAIRS *(Continued)*

Fig. 7—Earth-moving machines in operation during construction of the upper reservoir. In the foreground, a tracked bulldozer-ripper is breaking the ground

to the natural contours, the maximum height being about 35m and the mean height 14m. The rockfill is obtained by excavating the centre of the basin. The rock consists of schists and quartzitic sandstone and for the most part is readily broken up by bulldozer-rippers, although a certain amount of blasting is necessary. The material is picked up by scrapers, the loading operation being assisted in the usual manner by the bulldozers pushing (Fig. 7).

The broken rock, which is composed of particles of all sizes, is dumped on the dam site, graded, and rolled by the large pneumatic tyres of the scrapers and by special rubber-tyred rollers.

In addition to a number of excavating machines, the plant employed includes four Caterpillar " D9 " tracked bulldozers with front shield and three to five hydraulically-operated ripper tines at the rear. The number of tines can be varied to suit the resistance of the particular rock formation. Two Caterpillar " D8 " and two Hanomag " K60 " bulldozers are in use, as well as two graders, four " DW21 " scrapers, and two 50-tonne " Albaret " rubber-tyred rollers.

The rockfill, which is laid down on the previously cleared bedrock, is solidified layer by layer to a density of 2·1 tonnes per cubic metre, as compared with 2·7 tonnes per cubic metre for the grown rock.

A filter layer, the grading of which is still under consideration, will be placed over crown and inside slope as well as over the bottom of the basin. Watertight cladding is to be provided by a double bituminous layer with a combined thickness of 7cm. Cut-and-cover drainage culverts under the basin, including a combined drainage and inspection culvert all along the inside of the dam, serve the purpose of protecting the structure in case of leaks and at the same time allowing such leaks to be quickly located. The external face of the dam is being covered by a layer of topsoil and will be afforested. Excavation of the basin and construction of the dam for the first stage are scheduled to be substantially completed in the autumn.

Power House

All machinery and equipment of the power station will be housed underground. The main chamber is approximately 300m long by 17m wide by 30m high (14m high from machine floor to inner roof). Fig. 4 shows a plan view and Fig. 5 a cross-sectional elevation. Excavation began with a pilot tunnel along the centre of the chamber near the roof. This was widened across the full 21m span of the arched vault, which was concrete-lined section by section as the work proceeded, with inclined prestressed roof bolts being placed in the rock at the abutments (Fig. 8). Protection from water seepage will be afforded by an inner vault and by inner concrete walls spaced away from the rock face. On top of the walls, approximately 10m above floor level, will be placed the rails for the travelling crane.

At the outer end of the chamber are two maintenance bays slightly above machine floor level, and the control room at a raised level. The space between the concrete walls and the rock is wider here than elsewhere and is used for housing cables.

Between sets Nos. 1-4 and Nos. 5-8 a further maintenance area is to be provided. Each set occupies a floor space of approximately 14·5m by 30m, and the total maintenance area amounts to about 700 square metres.

The power-house is accessible through a 5m main adit which opens on to the principal maintenance floor. A 2·4m wide ventilation gallery connects the control room end with the outside. A second adit to the control room is provided by a gallery connecting with the dry lower part of the Stage I penstock (below the distributor section).

The transformers are housed off a separate 6m wide gallery in niches from which cable tunnels extend to the power-house. These cable tunnels and a further tunnel to the control room also serve as emergency adits in case of flooding, as the power-house is below the minimum reservoir level while the transformer gallery lies above the maximum level. From the transformer gallery shafts extend downwards to the discharge tunnel branches. In these shafts are housed the control.

Penstocks

The four sets of the first stage will be served by a circular intake structure built in the reservoir on the side facing the Our valley (Figs. 2 and 3). After a short vertical section, the penstock, which is steel-lined and has a diameter of 6m, curves towards the river and descends at an angle of approximately 30 deg. to the horizontal distributor section at 229·1m sea level. The total length of the penstock, from below the intake structure to the distributor, is 512·7m. The distributor comprises four similar branches with corresponding reduction of the main pipe in between. Each branch immediately divides again, one section connecting with the pump and the other with the turbine by way of control valves. Below the last branch the tunnel is sealed off by a concrete block containing an adit normally closed by a watertight door. The 4·5m diameter dry section then extends for about 140m to the outside at 227·5m sea level.

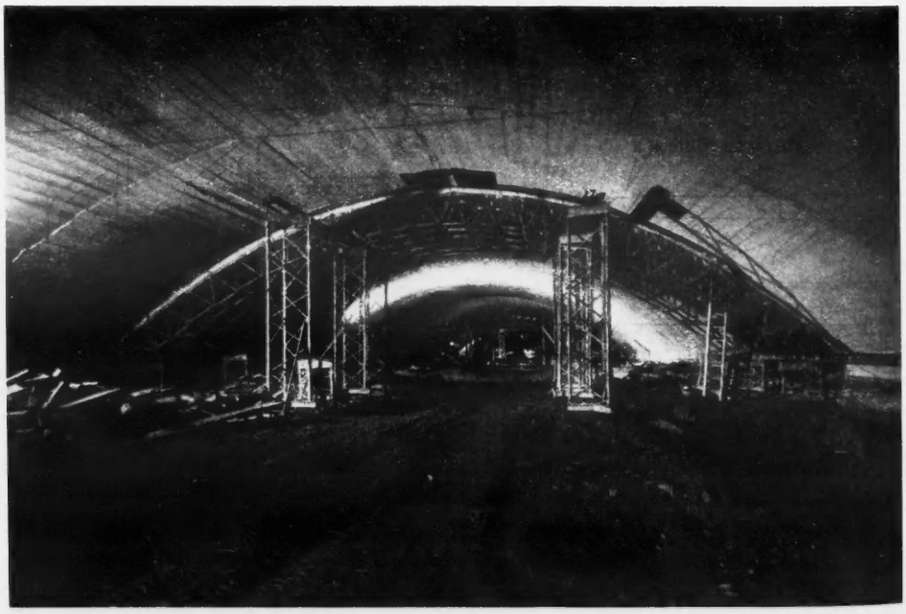


Fig. 8—Concreting the roof of the underground machine hall which is nearly 300m long. The full height of the chamber is now being excavated, beginning on either side and leaving until last a central embankment for lorry traffic

The turbine outlets and pump intakes are connected by short steel-lined sections to the concrete-lined discharge tunnel with axis rising towards the exit at about 211·7m sea level. The section here diverges to an equivalent diameter of 9m.

The intake for the second stage will be situated in the short dividing dam between the two halves of the upper basin. A penstock, 6m in diameter and 430·9m long, will connect the intake with the second distributor at 211·7m sea level. The second discharge tunnel, apart from its greater length, is constructed similarly to the first and connected to the turbines and pumps in the same way.

Operation

Vianden is situated within a radius of 150 km from the Rhine and Ruhr, the Lorraine industrial basin, and industrial centres in Belgium and, of course, Luxembourg itself. Because of its position near the Renish lignite field and other coal-mining areas, the station is favourably placed to receive cheap off-peak power for pumping, and to supply in return peak power to the neighbouring interconnected grid systems. The daily cycle will comprise eight hours' pumping and 4¼ hours' generation, or about 2800 hours' pumping and 1500 hours' generation in a year.

Machinery

As envisaged, the eight sets will have turbines of 100MW capacity each, with a discharge of 39·5 cumecs at 428 r.p.m., while the pumps will be laid out for 69MW each, delivering 21 cumecs. Generation will be at 13·8kV which will be stepped up to 220kV. There will be one transformer per set, with a capacity of 115MVA. Annual generation will total 1200 GWh. The machinery for Vianden is at present in its early stages ; this topic will be dealt with more fully in a later article. The table lists the general data of the plant.

	Stage I	Stage II
Number of sets	Four	Eight
Turbine installation	400MW	800MW
Pump installation	276MW	552MW
Transformer installation ...	460MVA	920MVA
Turbine discharge (total) ...	158 cumecs	316 cumecs
Pump discharge (total)	84 cumecs	168 cumecs
Upper reservoir (total capacity)	$2·75\times10^6m^3$	$5·5\times10^6m^3$
Lower reservoir (useful capacity)	$6\times10^6m^3$	$6\times10^6m^3$
Daily volume	$2·42\times10^6m^3$	$4·84\times10^6m^3$
Annual operation (turbines) ...	... ... 1500 hours	
Annual operation (pumps) ...	... ... 2800 hours	
Generation per annum	600×10^6kWh	1200×10^6kWh
Head of water (maximum) ...	... ... 290m	
Head of water (minimum) ...	... ... 267m	
Overall efficiency (estimate) ...	... ... Over 70 per cent	

Co-ordination of the project and the overall direction of the work is in the hands of Société Generale pour l'Industrie, Geneva. Project studies were carried out by Electrizitäts-Actien-Gesellschaft vorm W. Lahmeyer and Co., Frankfurt/Main, and Société de Participations et d'Etudes d'Installations Hydroelectriques "SOPADE," Luxembourg. These two firms are also responsible for the immediate direction of the work.

Main Contractors

Civil engineering.—Upper reservoir : Group comprising Polensky & Zöllner, Cologne ; Arthur Simon G.m.b.H., Cologne ; Leonhard Moll K.G., Munich ; Cie Belge de Chemins de Fer et d'Entreprises S.A., Brussels ; Strabag Bau A.G., Cologne. Intakes, penstocks, underground power station, transformer gallery, adits, discharge tunnels, river regulation and subsidiary work : Group " Vianden Power Station " comprising Hochtief A.G., Koblenz ; Wayss & Freytag A.G., Cologne ; Alfred Kunz & Co., Munich ; Entreprise E. Nennig, Luxembourg ; Losinger & Co. S.A., Lausanne ; Conrad Zschokke S.A., Geneva ; Cie Belge de Chemins de Fer et d'Entreprises S.A., Brussels. Lohmühle barrage and power station : Coehba et Satra, Paris and Luxembourg. Reconstruction at Bivels : P. Grach, architect, Luxembourg. Bore-holes and water services : Thielen-Bassing, Vianden. *Electro-mechanical.*—Pumps and turbines : Escher Wyss A.G., Zurich and Ravensburg ; Etablissements Neyrpic S.A., Grenoble ; J. M. Voith G.m.b.H., Heidenheim (Brenz). Alternators : Ateliers de Constructions Electriques de Charleroi S.A. (ACEC), Charleroi ; Siemens-Schuckertwerke A.G., Erlangen. Transformers : ACEC, Charleroi. Valves : Dinglerwerke A.G., Zweibrücken (Rheinpfalz). Pressure linings : VOEST, Linz ; Rheinstahl Union Brückenbau A.G., Gelsenkirchen. Valves, Auxiliary Turbines and Pumps : J. M. Voith, Heidenheim (Brenz) ; Fonderies et Ateliers de Mersch (FAMKSB), Mersch (Luxembourg). Upper and lower intakes (mechanical equipment) : M.A.N., Gustavsburg ; Karl Pühler Maschinenfabrik, Berg-Neustadt (Rhineland). Main travelling crane : Stahlbau Albert Liesegang, Cologne-Kalk. Ventilation and air conditioning : Luwa G.m.b.H., Frankfurt/Main. Overload protections, control panels : Siemens-Schuckertwerke, Erlangen. 6kV installation and 13·8kV generator-transformer connection : BBC, Mannheim. 245kV cables : Felten & Guilleaume Carlswerk A.G., Cologne-Mühlheim. Low tension cables : SAG Starkstromanlagen Gemeinschaft, Frankfurt/Main. Lohmühle Power Station : Maschinenfabrik G. Maier K.G., Brackwede (turbines) ; Schurch-Werke A.G., Rheydt (alternators) ; M.A.N. Gustavsburg (valves and steel linings).

Liner "Leonardo Da Vinci"

NOW in the Mediterranean–North American service of the "Italia" line is the liner "Leonardo Da Vinci" which was launched on December 7, 1958, by Madame Gronchi, the wife of the President of the Italian Republic, and was built by the Societa Azioni Ansaldo in its shipyard at Sestri Ponente, Genoa.

The principal particulars of the liner are :

Length overall	760ft
Length between perpendiculars ...	677ft
Breadth moulded	92ft
Depth moulded to Promenade Deck	69ft
Draught mean	31ft 1in
Displacement	33,000 tons
Gross tonnage	33,000 tons
Cruising speed	23 knots
Passengers :	
First class	413
Cabin class	342
Tourist class	571
Total	1326
Machinery :	
Two sets double-reduction geared turbines	70,000 s.h.p.
Four Foster Wheeler boilers :	
Steam pressure	668 lb per square inch
Steam temperature	842 deg. Fah.
Five turbo alternators, each	1100kW
Four diesel alternators, each	600kW

The main hull, which is mainly of prefabricated welded construction, incorporates about 12,000 tons of steel, while approximately 200 tons of aluminium alloy were used for the superstructures. There are eleven decks of which four extend over the whole length of the ship, the bow is of streamlined bulbous form and the stern is of cruiser shape. A total of fourteen watertight bulkheads, thirteen of which extend to the upper deck, divide the ship into fifteen compartments and the double bottom, which has tanks for fuel oil, fresh water, lubricating oil and ballast water, extends from peak to peak. The bulkheads are fitted, as required, with remote and locally controlled, power-operated watertight doors to the number of thirty.

All the accommodation is air conditioned, the equipment consisting of three groups of Carrier-Termomeccanica units with centrifugal compressors and an overall rating of 3,000,000 B.Th.U. per hour. For the working spaces mechanical ventilation is provided. There are seven lifts for use of the passengers and two serving the deck and engineer officers, while six more are stores and service lifts. Two garages, one of which has direct access from the pier, are provided and have a capacity of fifty cars. The kitchens are all electric and the equipment has a total load of 666kW. For the comfort of the passengers two sets of Denny-Brown stabilisers are fitted, each set consisting of two fins 10ft 1in long by 6ft wide, and able to reduce a roll of 20 deg. to about 2 deg. The ship is divided into fire restricting zones by fireproof bulkheads and doors: in the accommodation there is a Grinnell sprinkler system, while a Lux-Rich CO_2 system is installed in the cargo spaces. To deal with boiler-room fires a mechanical foam system has been installed.

To handle cargo at Nos. 1 and 2 hatches there are two 10-ton, two 5-ton and four 3-ton derricks, and one 30-ton heavy derrick, all operated by four 5-ton and four 3-ton electric winches. For serving the cold storage cargo, mail and baggage there are a total of nine conveyor belts having a capacity of 134 lb per foot length. Three "Freon 12," twelve-cylinder Vee Carrier compressors serve the holds and cold stores and are driven by electric motors at speeds ranging from 1180 to 1750 r.p.m., the maximum output being 14,000 B.Th.U. per hour.

Propulsion of the liner is by two sets of double-reduction geared turbines, each of which has a normal power of 35,000 s.h.p. and takes steam at 668 lb per square inch and 842 deg. Fah. from four Foster Wheeler pattern watertube boilers. The machinery is arranged in two separate groups, each consisting of an h.p. and an l.p. turbine with an astern turbine incorporated in the l.p. turbine casing and two boilers, each of which has a double combustion chamber and a heating surface of 12,000 square feet. These groups are located in two compartments, there being aft and forward machinery spaces, one per shaft. Propellers of a special bronze alloy and having a diameter of 20ft and weighing 22 tons are fitted and the ship has a normal cruising speed of 23 knots. On trial a speed of 25·41 knots was maintained for nine hours and about 50,000 s.h.p. was developed per shaft.

A Weir closed feed system is installed and includes "Regenerative" condensers, having a total tube area of 38,800 square feet, and being fitted with direct-operated closed feed control valves. There are four "Lo-hed" vertical, electrically-driven, main extraction pumps, each having an output of 132,000 lb to 204,500 lb per hour and a maximum load discharge pressure of 35 lb per square inch. From the extraction pumps, the condensate passes through four three-stage steam jet air ejectors of "Maxivac" vertical inter-condenser pattern operated by steam at 427 lb per square inch and 824 deg. Fah: the ejectors maintain a vacuum of 28·65in Hg. when extracting 64 lb of air per hour. Feed water is supplied to the boilers by four T.M.F.P. 27 turbine-driven, three-stage barrel casing pumps, two working and two standby, each rated to discharge 231,420 lb to 298,642 lb per hour against a pressure of 800 lb per square inch. Also provided by G. and J. Weir, Ltd., are two "Robot" auxiliary boiler feed regulators designed to withstand a boiler pressure of 140 lb per square inch and capable of passing 20,000 lb of feed water per hour.

In a compartment between the main engine-rooms are placed the two oil-fired watertube auxiliary boilers, each having a heating surface of 4089 square feet and an operating pressure of 142 lb per square inch. In the same space are three evaporator and distiller units, each of 200 tons per twenty-four hours' capacity, and two mineralisation plants. There is water storage capacity amounting to 17,650 cubic feet.

THE AMERICAN SCENE

by Our American Editor

Applications of Automatic Data Processing at the N.B.S.

No. I

In the field of automatic data processing systems the National Bureau of Standards serves the U.S. Government as a central research and development agency and a readily available source of technical information. The scope of the programme in data-processing applications and equipment design is illustrated in the development of methods for solving specific problems in both scientific and management areas, explorations of the potentialities of computers, logical design of computing systems, development of special circuitry, and evaluation of electronic components. This programme was initially established to assist the Bureau and other government agencies in finding solutions for their data-processing problems and has now grown with the electronic computer art to include a wide range of research and development activities.

The research laboratories of the National Bureau of Standards, as well as laboratories in other government activities, have become increasingly aware of the time required to record and process experimental data before it reaches the high-speed computer that is used for final processing. Recent surveys have resulted in the identification of dozens of projects in which this bottleneck can be removed through the use of analogue or digital techniques. One result of the studies on circuitry has been the development of a series of flexible transistorised computer packages that can be combined to create specialised data recording and processing equipment for input to a large-scale digital data processor. These packages were the direct outcome of efforts to "automate" some of the routine data handling associated with scientific experimentation in government laboratories. The automatic data analyser developed for the U.S. Weather Bureau and described below, is an example of the way they can be interconnected to meet a specific data-logging requirement. Concurrent with the work on problems of data recording has been the development of specialised computer programmes for particularly difficult design problems. Another challenging research activity relates to the ever-increasing problem of information storage, search, and retrieval. This work has taken two forms: the development of an improved model of a microfilm rapid selecting device, based on a concept originally proposed by Vannevar Bush nearly a quarter of a century ago, and the development of special computer routines applicable to experimental machine search. Both the rapid selector and an initial experiment to test its operation are briefly described below. A computer programme known as HAYSTAQ because of its similarity to the well-known simile concerning finding a needle, has been developed in co-operation with the U.S. Patent Office. With this programme, a high-speed computer simulates certain features of the kind of search a patent examiner makes in analysing a patent application. Another computer programme which simulates certain logical recall operations and which illustrates a limited degree of "machine learning" was developed and successfully demonstrated. Transistors and magnetic cores are increasingly being utilised in the development of improved computer circuitry. The transistor-magnetic core circuit, originally developed under a continuing U.S. Air Force project for improvement of computer components and circuitry, has been modified to provide a compact low-power pulse repeater of improved stability and increased logical gain. A small computer was built as a circuit test device, and is reviewed here.

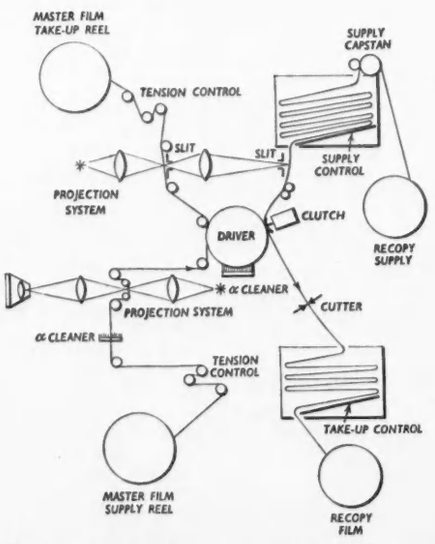


Fig. 1—Diagram of film transport system for rapid selector document retrieval device

The Rapid Selector

The Bureau has developed an improved model of an automatic document-retrieval device for the U.S. Patent Office and the U.S. Navy Bureau of Ships. The machine rapidly retrieves information from massive files of correspondence, drawings, patents, or similar printed matter which have been recorded on 35mm microfilm. Associated with each document image is a binary dot code which identifies the content of the document. The machine examines these codes rapidly—about 2400 pages per minute—and when a desired document is found, photographs it on a strip of recopy film. The rapid selector is an out-growth of an idea originally proposed by Dr. Vannevar Bush more than twenty years ago. More recently, Yale University undertook the redesign of the machine to meet its own special requirements in document search. Subsequently, the Patent Office and the Bureau of Ships asked the National Bureau of Standards to study the machine to see how it could be further changed to meet their particular needs. For this programme, the Bureau obtained a portion of the Yale equipment, modified the optical and mechanical systems, and redesigned the electronic circuitry using modern computing machine practice.

The machine identifies the required document by examining a binary dot code associated with each document. A single code frame is about ¼in long and as wide as the film, and contains six rows of forty-six bits each; forty bits are for document information and six bits are for machine control. The mechanism that reads these rows of bits has sufficient tolerance to allow for normal dimensional changes in the film and slight skew in the rows (Fig. 1). As the film passes through the machine, its image is projected on a bank of photocells which scan the code. When a desired item is found, a high-speed clutch mechanism is activated. This clutch presses the recopy film to a drive drum, accelerating it to the same speed as the information or master film. By means of slit photography the desired item on the master film is registered on the recopy film. After the desired item passes the camera slit, the clutch is disengaged and the recopy film stops. As many consecutive items as desired can be copied without slowing or stopping the master film. The output of the machine is a recopy film (Fig. 2) on which are registered all the documents of interest.

To test the operation of the rapid selector, a test film was prepared. It contains the contents of the *N.B.S. Technical News Bulletin* for about a ten year period to show the wide variety of subject material that can be located with the selector. In all, more than 250 individual categories, simply or in combinations, were used in the index to describe the 900 articles. Successful searches on this test

Fig. 2—Re-copy film being threaded into the rapid selector machine

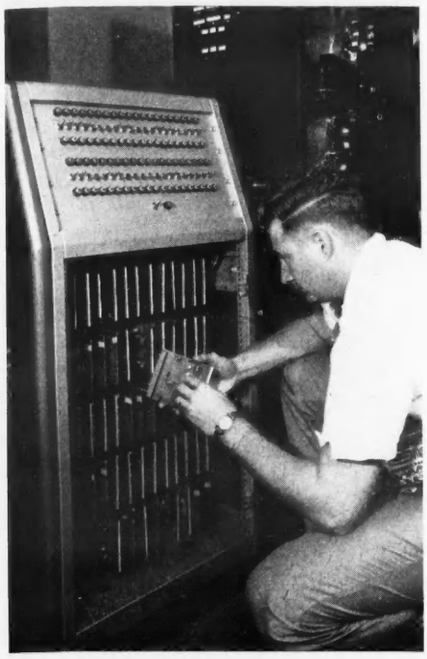


Fig. 3—" Packaged " printed circuit board being inserted into machine control console

film have shown the practicality of the system.

The present selector is limited to using only one word per document. This word can represent many combinations of concepts. An improved electro-mechanical film transport combined with a multi-word selector, now under construction, will perform much more rapid and sophisticated searches than the present machine. In the improved selector, signals caused by the recognition of the machine words can be combined using computer logic to give the print-out command. A six machine-word code has been devised with which the Bureau of Ships is encoding a series of letters to be used in an encoding study. With this code system they will be able to find any letter or letters, written between certain dates, from a particular supplier about a specific type of equipment.

Cloud-height Data Analyser

The National Bureau of Standards has developed a special-purpose computer for the U.S. Weather Bureau to analyse data received from a ceilometer, or cloud-height indicator (Fig. 4). On command, this small-scale data processor will tell an operator not only what the cloud height is at present but what the highest, lowest, or predominant cloud height was at any time in the last ten minutes, or how often clouds occurred below some critical level during this same period. The instrument was developed by the data processing system laboratory as part of a programme to assist and advise the Weather Bureau in applying computer techniques to automatic weather data analysis.

The cloud height is obtained by means of a device known as a ceilometer that can measure the height of clouds from the ground up to about 10,000ft. A light beam from a searchlight is reflected by the clouds and is received by a photocell placed at a known horizontal distance from the searchlight. Either the light or the photocell is rotated through an angle of 90deg. The cloud height is calculated by simple triangulation, using the angle at which the reflection from the cloud is received, and the known baseline. The light source is modulated by a rotating shutter, and the photocell operates in conjunction with a filter and a tuned amplifier to discriminate against ambient light. The ceilometer scans the cloud ten times per minute.

The ceilometer indications are observed by an operator who interprets a cathode-ray display and obtains by manual computation answers to a variety of questions. Typical questions might be: At what height did most of the clouds occur over the past ten minutes? What was the lowest level at which a significant number of clouds occurred? The cloud height data analyser automatically finds the answers to these questions, thereby relieving the operator for more important duties. To do this, the cloud-height data-analyser (Figs. 5 and 6) samples the ceilometer output and records the height at which the greatest signal is received during each scan. These data, which represent the most recent ten minutes of information, are stored in a small 100-word magnetic drum memory. After each scanning of the clouds there is a short period of time during which no information is being received; during this time the stored data are analysed. The output of the equipment is a set of answers pertaining to the last ten minutes, updated each scan.

The inputs to the equipment consist of two signals. One is a shaft-position signal from the rotating searchlight, consisting of a series of pulses. The other is an a.c. signal from the photocell at the modulation frequency of the light source. The shaft position pulses advance an altitude counter whose count is related to the angle of the searchlight. The angle is in turn related to cloud height, which may be as high as 10,000ft. The photocell signal is passed through an analogue-to-digital converter which samples the signal in synchronism with the modulated light source. At the end of each scan, the equipment has determined the altitude number corresponding to the maximum cloud signal. This number is recorded on the magnetic drum memory in one of 100 spaces. The numbers from successive scans occupy consecutive spaces on the drum. The 101st number will replace the original number in space number 1, which was recorded ten minutes earlier. Thus, the data are continually being updated.

Between scans, the data are summarised to determine which number occurs most often. At the end of this summation, an information storage unit contains the altitude which occurred most frequently over the past ten minutes. Other questions can be answered by using counters and additional storage units to find the highest or lowest altitude at which the maximum cloud signal was observed three or more times. The various outputs from the cloud height equipment are decoded to decimal numbers which are set up as switch contacts to control remote displays and teletype equipment. Except for the output switches and magnetic drum, the equipment is entirely transistorised and was made almost exclusively digital in operation to ensure a high degree of reliability.

Computer Routine For Logical Recall

The Bureau has developed a computer routine that simulates certain logical "remembering" operations. The routine was designed to illustrate some of the potentialities that high-speed electronic data-processing machines may have for automatic information retrieval, literature searching, or routing, classifying, and indexing of printed matter. This machine model of recall was devised by the data processing systems laboratory and has been successfully demonstrated on the "SEAC" computer.

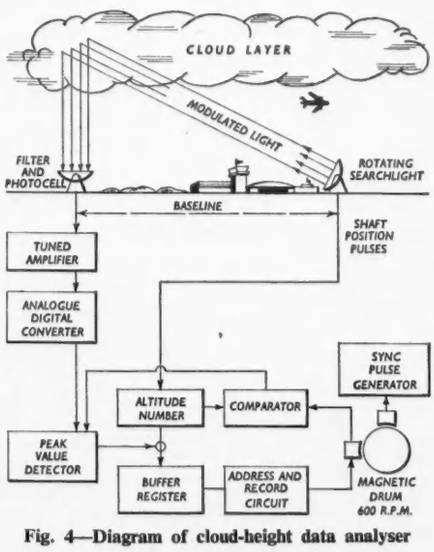


Fig. 4—Diagram of cloud-height data analyser

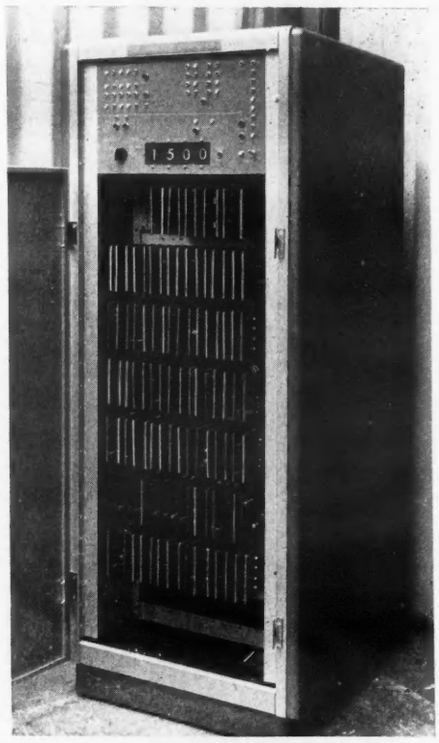


Fig. 5—Front view of the cloud-height data analyser cabinet showing the printed circuit packages

Since the turn of the century the tremendous increase in all forms of technical literature has made ever more difficult the task of the engineer and scientist in finding material relevant to his field of interest. Only in the last few years has attention been given to mechanised means for rapid, thorough literature searching and information retrieval, although interest has now become widespread. The use of high-speed data-processing equipment appears to offer a promising way of searching and retrieving written matter with speed and consistency. As part of a general study of automatic information selection, the Bureau devised the present computer routine to explore the possibilities of pattern recognition at the level of a "thesaurus lookup," limited machine learning, and simple verbal reasoning through verbal selection and recall operations. The routine provides the investigator with a method for studying a number of aspects of the logical recall problem. Firstly, the recall operations upon the information stored within the computer memory represent a special case of information selection and retrieval. Secondly, the machine routines provide easily understood illustrations of the potentialities the machine has in aiding certain auxiliary operations. These operations include machine reformulation of search questions in accordance with results already obtained, preliminary routing of incoming material to the appropriate geographic or subject matter location, and rudimentary machine indexing. Thirdly, the routines include prototypes of matching operations that may have direct applicability in certain practical information selection situations. Fourthly, the programme is designed to simulate various steps in pattern formulation and recognition and to exhibit a limited degree of machine learning.

The programme itself consists of an initial vocabulary of terms (nouns, adjectives and proper names) that can be recorded in the machine memory, together with clues to some of the logical and semantic relations between the terms. The programme also includes routines for various operations upon the store of "knowledge" of the machine as available at any one time. A small sample of such a

THE AMERICAN SCENE *(Continued)*

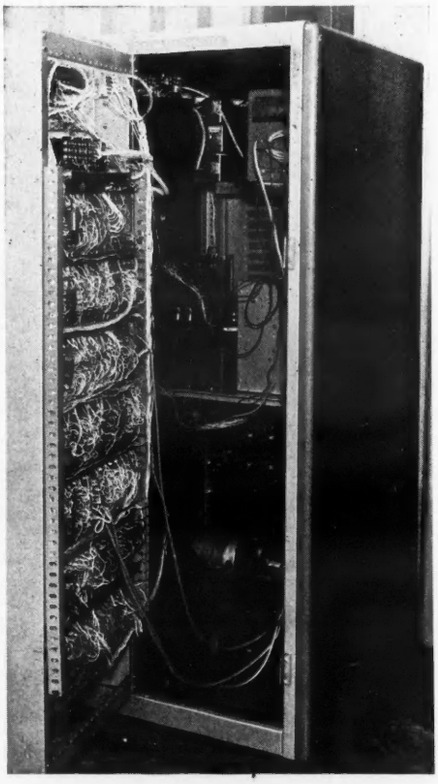


Fig. 6—Circuit packages swung out of the cabinet to provide access to the wiring connections

Fig. 8—Cyrillic character being mounted on a scanning device for information input to a computer

vocabulary is shown in Fig. 7. It should be noted that the programme is called "IQ", not because it demonstrates intelligence, but because it can provide correct answers to questions of a kind sometimes encountered in intelligence tests.

As shown, the vocabulary terms are arranged alphabetically in one section of machine storage, and in a directly corresponding section are clues to other related terms. Thus the first word, "arsenic" is cross-referenced to the term found in storage cell 521, "rodent destroyer". Other cross-reference tag positions are left blank in the illustration—either because the machine model does not yet know about certain other relationships, or because the referral would be to terms not shown in this example. The present size of the actual vocabulary used with "IQ" is limited to 256 vocabulary terms, but the vocabulary is expected to grow and change in the course of future experimentation.

SAMPLE IQ FILE

MEMORY CELL	CONTENTS	MEMORY CELL	CONTENTS
501	ARSENIC	601	21-00-00-00-00
502	BIRD	602	04-13-00-00-00
503	BURGLAR PROT.	603	00-00-00-00-00
504	CAGE	604	20-00-00-00-00
505	CANARY	605	02-04-19-00-00
506	CAT	606	15-18-19-21-00
507	DOC. No. 001	607	09-22-00-00-00
508	DOC. No. 002	608	06-09-00-00-00
509	DOG	609	03-10-15-18-19
510	DOGHOUSE	610	20-00-00-00-00
511	FISH	611	13-00-00-00-00
512	GUPPIES	612	11-19-00-00-00
513	LIVING THING	613	00-00-00-00-00
514	LOCK	614	03-16-00-00-00
515	MAMMAL	615	13-00-00-00-00
516	MECHANISM	616	00-00-00-00-00
517	MOUSE TRAP	617	16-21-00-00-00
518	NUISANCE	618	00-00-00-00-00
519	PET	619	13-00-00-00-00
520	POSITION	620	00-00-00-00-00
521	ROD DESTRYER	621	00-00-00-00-00
522	SALESMAN	622	15-18-00-00-00
523	TRUCK	623	16-18-00-00-00

Fig. 7—Sample "IQ" vocabulary developed for logical recall operations performed on an electronic computer

As an example, suppose that the machine is given an initial vocabulary consisting of the names of all the American Presidents, together with information about each man. This information might include the number of terms he had served, whether or not he was a general, his party affiliation, whether he is alive or dead, and any additional facts for which the machine has memory space. Once the machine has this initial set of facts and a set of routines to carry out several operational commands, it is prepared to carry out a variety of recall operations as specified by the machine operator. If he asks the machine to "define" the term "Lincoln", the printout will contain all the other terms associated with Lincoln. If he asks to "Extend" the term "Whig Party", he will obtain a list of all the presidents who were Whigs. A "Locate" command will select from all the recorded facts associated with one man only those that have to do with geographic association, e.g., "Lincoln" with "Illinois".

More complicated cross-reference systems can be generated as the questioning and directing of the machine programme proceeds. For instance, the operator can ask the machine to develop files of facts common (or not common) to sets of Presidents, to show how these files can be interrelated, and to find the appropriate cross-reference when given several input terms.

Communication with the machine can be by various input devices. The input means can include an automatic scanning device that "reads" a printed character which the programme recognises and, from a series of such characters, builds up a "word" that it then submits to a dictionary "lookup" operation. The more usual method of using the IQ programme for experiments in selective recall is by means of a teletype-writer, with which the operator inserts operational commands; the machine then prints out answers or programme cues, as required. The master IQ routine provides first for the identification of an input word, inserted by the operator, designating the type of elementary recall operation the machine is to perform and the selection of the appropriate sub-routine to perform the assigned task. As necessary, additional instructions for more complex operations are read in from magnetic wire or tape. When ready, the machine calls for input of one or more terms on which it is to operate. When these terms are received, the machine proceeds to carry out its assigned task.

The machine can also be given rules to suggest how the programme can be most efficiently carried out. Moreover, the operator can give the machine additional facts at any time, with instructions to the machine to correlate these items with facts already in the memory. In addition, provision is made for the machine programme to accept from the operator or from other input means a hitherto unknown term occurring together with familiar terms which share one or more associations. The routine can provisionally assign to the new term the cross-references which the accompanying terms have in common, thus displaying a very limited degree of machine "learning". The machine handles these new facts on a trial-and-error basis, informing the operator of its tries as the programme proceeds. The operator can tell the machine whether the tries are correct or not; the machine will "remember" only the "correct" relationships.

Obviously, the machine can operate only on those facts which are stored in its memory, and cannot invent new facts. However, it can, on command, generate complex sets of relationships between sets of facts that can be useful in indexing or finding data quickly. This machine process may seem to simulate human mental processes such as learning by association. However, the machine programme does not attempt to follow the organisational patterns that may be utilised in the human memory. Instead, the objective is to explore efficient machine organisation for operations that also happen to be performed by the human mind.

(To be concluded.)

Bonding of Dissimilar Metals

The firm of Ladd and Little Incorporated of Huntington Station, Long Island, New York, has been established by former technical and administrative executives of the Al-Fin Division of the Fairchild Engine and Airplane Corporation, to offer, on a consulting basis, techniques for metallurgically bonding aluminium or magnesium to steel, iron, nickel, titanium, &c. Typical examples of their experience in design, development, and production techniques include aluminium-bottomed stainless steel cooking utensils made under their direction by concerns in Germany, Switzerland, England, Australia, Sweden, Italy, the United States and Canada; armoured ring and pistons which are used throughout the world in heavy-duty I.C. engines; and aluminium brake drums with bonded-in cast iron braking surfaces as used by Mercedes-Benz on all models since 1953 and by B.M.W. as well as by Buick and Pontiac in the United States.

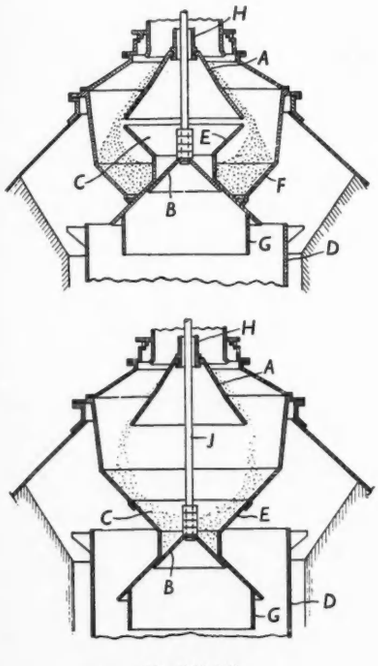
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

BLAST FURNACES

841,670. August 22, 1958.—CHARGING DEVICES FOR SHAFT FURNACES, Huttenwerk Salzgitter Aktiengesellschaft, Salzgitter-Drutte, Germany. (*Inventors: Paul Rheinlander, Heinz Schumacher and Josef Biasutti.*)

The invention is concerned with a charging device for shaft furnaces, especially blast-furnaces, which is of simple construction and enables the material to be discharged either in the centre or at the periphery of the furnace, as desired. It makes use of elements which are usually employed also in conventional charging devices and any additional parts can easily be introduced or replace those already used in the known designs. A charging device in accordance with the invention is illustrated, by way of example, in the accompanying drawing. The charge is directed



No. 841,670

towards the periphery of the furnace, in the following manner. The hopper is charged by lowering the upper bell *A* when the lower bell *B* and an intermediate member *C* resting on it are in the closed position. The charge is thereby delivered into the annular space between the funnel-shaped part of the hopper and the intermediate member. By lowering the lower bell and the intermediate member at the same time, the hopper is opened and the charge delivered to the periphery of the furnace over the conical surface of the intermediate member *B*. The charge is prevented from directly impinging on the brickwork by the steel apron *D*. The method of delivering the charge to the centre of the furnace is as follows. Before lowering the upper bell *A*, the lower bell *B*, together with the intermediate member *C*, is lowered until the surface of the funnel-shaped part *E* of the intermediate member lies in the same plane as the funnel-shaped part *F* of the hopper, as shown in the lower view. On opening the upper bell the charge falls into the space formed by the hopper and the intermediate member, which is closed by the lower bell. When the bell is lowered, the charge, with the guidance of the cylinder *G*, falls into the central part of the furnace. With the apparatus of the invention only two bells need be actuated and only two bell-carrying elements are necessary, namely a tube *H* and a rod *J* which is movable in the tube. The charging device is provided with two independent means for actuating the lower bell. These elements act through an additional gear on the rod *J*. The stroke of one of the driving elements corresponds to the opening and closing movement of the bell *B* and the stroke of the other driving element corresponds to the movement of the intermediate member *C* from one end position into the other.—*July* 20, 1960.

LOCOMOTIVES

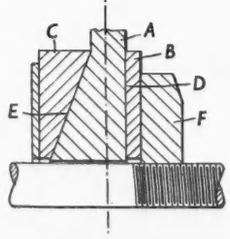
841,963. October 10, 1958.—TRANSMISSION, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor : Louis Frederick Rudston Fell.*)

This invention relates to an improved locomotive power unit. Its object is to provide a unit which will be capable of continuous operation over a very wide range of speeds. This object is achieved by a power unit comprising at least two engines, each engine being connected through a torque converter to a gearbox arrangement. The output of this gearbox is connected directly or indirectly to a driving axle or wheels of the locomotive, means being provided to prevent reverse rotation of the output member of each torque converter when the engine associated with it is inoperative. A locomotive power unit embodying the invention is particularly useful in shunting engines which are required to operate continuously at speeds within a range which may be as much as from 0·5 to 20 m.p.h. At the low speed end of the range the power required is very small and in a two engine arrangement the power can be easily provided, economically, by one engine. By using only one engine and its associated torque converter the engine will be run at a higher speed and a higher load than it would if both engines were used. At this higher speed the efficiency of the engine and of the torque converter are greater than at very low engine speeds. The specific fuel consumption of the engine is lower and therefore the use of one engine with torque converter is more efficient and economic, at low speeds, than the use of both engines. By employing a torque converter associated with each engine, either engine can be employed alone for low-speed shunting. The specification includes details and drawings of this design of transmission equipment.—*July* 20, 1960

TURBINES

841,715. August 29, 1958.—ROTORS, Power Jets (Research and Development), Ltd., 25, Green Street, London, W.1. (*Inventor : James Brown.*)

This invention relates particularly to rotors for turbo-machines. It is known to secure a rotor disc to a shaft passing through a bore in the disc by clamping means, such as a bolt, engaging the shaft and abutting one face of the disc. When such a disc is rotated at high speed, radial stresses are set up which produce both a radial tensile strain and a lateral compressive strain. It will be appreciated that the compressive strain results in an undesirable slackening of the tension afforded by the clamping bolt. According to the invention there is provided a rotor having a portion which tapers out from the rotor axis and which is arranged to be engaged by clamping means, the tapered portion having end faces arranged to mate with the clamping means, and the



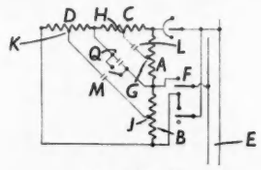
No. 841,715

sum of the cotangents of the angles between the end faces and the axis of rotation being substantially equal to Poisson's ratio for the material of the rotor. An embodiment of the invention is described, by way of example, with reference to the accompanying diagrammatic drawing. A rotor disc *A* is mounted on a shaft and each end face of the rotor abuts against distance pieces *B* and *C*. One face, *D*, of the rotor lies in a plane perpendicular to the axis of the shaft. The other face of the rotor *E* is conical, the cone angle being such that the cotangent is equal to Poisson's ratio for the material of the rotor. If the rotor were of mild steel the cotangent of the angle would be equal to 0·3. The distance piece *C* has one face of complementary form to that of the rotor face and the other face lies in a plane perpendicular to the axis of the shaft. The perpendicular face abuts against a washer which in turn abuts against either an abutment on the shaft (not shown) or another rotor assembly, A nut *F* serves to clamp the distance pieces and the rotor together in co-operation with either the abutment on the shaft or another fixture. In operation, once a given force is applied to the nut this force should be maintained. As a result of centrifugal force the rotor is tensioned, thus producing a contraction in its thickness and hence a slackening of the force exerted by the nut. By designing the rotor with an inclined face, the outward movement of any given point on the inclined face is counteracted by a movement parallel to the shaft axis. The net effect is that the effective distance between the faces *D* and *E* is not decreased and, in fact, a sliding movement takes place between the mating faces of the disc and the distance piece *C*. In another embodiment illustrated in the specification in place of the rotor with one inclined face and the other face in a plane perpendicular to the shaft axis, both faces are inclined to the shaft axis, the angles of inclination being such that they are equal and that the sum of the cotangents of these angles is equal to Poisson's ratio for the material of the rotor. This design gives the same advantages as that shown. —*July* 20, 1960.

ELECTRICAL ENGINEERING

841,575. September 19, 1956. — SINGLE-PHASE MOTORS, Aktiebolaget Scania-Verktyg, Postbox 7032, Halsingborg, Sweden.

The present invention relates to two-speed single-phase motors. The stator windings hitherto known for single-phase motors, which by re-grouping change the number of poles in the relation 1 to 2, have the disadvantage that they give the motor poorer qualities at either the higher or the lower number of poles. It is an object of the invention to provide a single-phase motor which works fairly well at both numbers of poles, which is best attained if the magnetic flux in such cases stands approximately in the relation 1 to 2 to the other. According to the invention there is provided a two-speed single-phase motor having its stator windings arranged for changing the number of poles in the relation 1 to 2, characterised by the windings comprising a main winding consisting of



No. 841,575

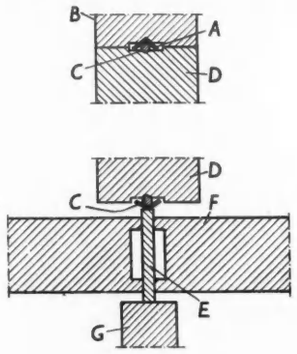
two equal parts and an auxiliary winding also consisting of two equal parts. At the lower number of poles the parts of the main winding are connected in parallel with each other and serve as a working winding, the parts of the auxiliary winding being also connected in parallel with each other and arranged magnetically in quadrature to the main winding to serve as a starting winding. At the higher number of poles both parts of each winding are connected mutually in series and the two windings so obtained are connected in parallel with each other to serve as common working windings connected to the line. Both parts of the main winding are connected by means of at least two condensers to both parts of the auxiliary winding. Referring to the drawing, *A* and *B* indicate the two parts of the main winding whilst *C* and *D* indicate the two parts of the auxiliary winding which are connected to the power supply *E* by means of the three-pole switch *F*. The stator windings are required to be symmetrical and potentials arise between *G* and *H* and *J* and *K*, by reason of the cross-field generated in the motor, even if the total potentials in the windings *A* and *C* or *B* and D coincide completely, thus causing currents through the condensers *L* and *M* which, with the greatest number of poles increase the motor torque when the motor is running and improve its power factor. The condenser *L* being connected between *A* and *H* and the condenser *M* between *J* and *K* as shown, the motor starting torque is only slightly reduced at the lower number of poles connection. An alternative connection is shown in the specification whereby the motor starting torque will be slightly reduced in the case of the lower pole number connection, whilst with the higher pole number connection motor torque is increased. The condenser *Q* which effectively contributes to the

starting torque in the case of the lower pole number connection can be left out if no greater starting torque is required with this pole number connection.—*July* 20, 1960.

SAW BLADES

841,801. September 25, 1958.— BAND SAW BLADES, Allmanna Svenska Elektriska Aktiebolaget, Väasteras, Sweden.

The invention relates to a method for manufacturing saw blades, especially band saw blades and in particular to blades in which the tips of the teeth are of high-speed tool steel with the main part of the blade of carbon steel or a low alloy steel. According to the invention a reliable welding joint is obtained by introducing by rolling a thin band of stainless steel or similar material between the body of the saw blade and the strip intended to form the teeth. The drawings



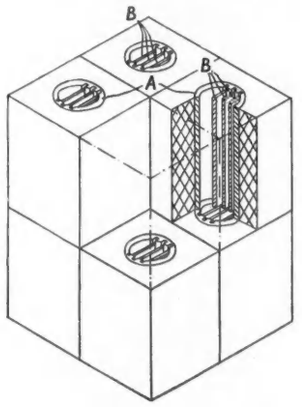
No. 841,801

show how in the process of manufacture a thin band *A* of stainless steel runs in a slot formed in a roll *B* and in this slot there is a deeper vee slot into which the stainless steel band is forced by a high alloy strip *C* when the latter enters between the rolls *B* and *D*. This causes the band to be deformed with a longitudinal groove. The lower view shows how the grooved thin band and the strip are brought into contact with a carbon steel band *E* which is to form the body of the saw blade. The welding current is delivered to the welding point between the carbon steel and the thin stainless steel bands and the strip by contact or guiding rolls *F*, and is led from the welding point by the roll. The guiding rolls have slots which concentrate the delivery of current to a point on the band *E* close to the welding point. *G* is a guide roll which keeps the band pressed against the stainless steel band running in the slot on the roll *D* and the high alloy strip. The high alloy strip is generally of high-speed tool steel and preferably is of hexagonal cross section, but it may be of any other suitable section. By employing a strip of hexagonal section a concentrated transmission of the current to the stainless steel and carbon bands is obtained.—*July* 20, 1960.

NUCLEAR POWER

841,992. November 22, 1956.—NUCLEAR REACTORS, Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 1-3, St. Paul's Churchyard, London, E.C.4, and The British Thomson-Houston Company, Ltd., Crown House, Aldwych London, W.C.2. (*Inventors : Selchouk Ahmed Ghalib, George Erasmus Darwin and Peter Raymond Joseph French.*)

This invention relates particularly to uranium fuel elements for reactors having a solid moderator such as graphite. Reactors of this type are usually built of a stack of graphite blocks formed with channels which are usually either vertical or horizontal and which house fuel elements and also form passages along which the coolant flows. In such reactors the graphite immediately around the channels is subjected to bombardment by neutrons of high energy which causes these parts of the graphite to deteriorate at a relatively greater rate than the remainder. The main object of the invention is to provide an improved arrangement of fuel element in which these disadvantages are avoided or at least minimised. The fuel elements are arranged in units each constituted by two or more plates or slabs of fuel material mounted in hollow ducting of solid moderator material, e.g. graphite, adapted for insertion in fuel passages in the reactor moderator, the arrangement being such that the fuel plates extend longitudinally along the ducting and are spaced apart laterally to provide passages for the coolant. The ducting may conveniently be of tubular or of hollow rectangular section and it may be formed internally with longitudinal grooves into which the edges of the fuel elements fit. A number of such fuel units may be located in the reactor channels end to end. In the case of vertical channels the fuel elements are preferably slightly shorter than the ducting so that the ducting sections rest on each other and the fuel elements are relieved of stresses caused by the weight of the units above them. The accompanying drawing shows a part sectional view of a graphite core stack having vertical channels.



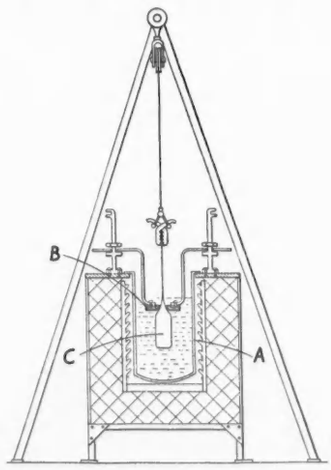
No. 841,992

The reference *A* indicates the cylindrical graphite carrier. The interior of the carrier has longitudinal grooves into which fit the fuel, e.g. uranium elements *B*. These elements are shown in the form of three plates spaced apart to form passages for the coolant which will normally be a gas. The fuel elements will, of course, be encased in accordance with normal practice. Other forms of construction are described in the specification.—*July* 20, 1960.

METAL FORMING

843,362. September 20, 1957.—HOT SHAPING OF METALS AND METAL ALLOYS, Deutsche Gold-und Silber-Schiedenstalt Vormals Roessler, 9, Weissfrauenstrasse, Frankfurt (Main) 1, Germany.

The shaping of metals and alloys to produce sheets, bars or wires by rolling, drawing or extrusion presents particular difficulties in the case of materials which are only sufficiently ductile under heat, and which have a high affinity for oxygen or other constituents of the atmosphere. The heating of the workpiece cannot always be carried out in the appropriate protective gases and, where possible, such treatment involves large expenditure in the provision of special furnaces. It has now been found that it is possible



No. 843,362

to shape metals and alloys which are plastic under heat, and especially those which are sensitive to oxygen, by extrusion or drawing to reduce their cross-sectional area, with better results in regard to dimensional accuracy, surface quality and structure formation, if the blank is dipped into a salt melt or coated on the surface with salt or salt melt which is maintained on the surface both before, during, and after shaping. Depending upon the hot strength of the material and upon the tool employed, the reduction of the cross-sectional area of the material may be carried out either after the workpiece has been removed from the salt melt or directly in the salt bath. The latter method of operation is regarded as preferable for drawing, in which case the die is disposed within the salt melt in the neighbourhood of the surface of the bath, and thus the tip of the drawn article is coated on the surface with the salt when it is withdrawn from the bath. In the case of extrusion, the blank is removed from the bath and introduced into the shaping tool. The salt mixture adhering to the blank is for the greater part forced out of the pressing chamber in the direction of the ram when the blank is pressed against the die and the walls of the ingot container, and protects the ingot from the influences of the atmosphere. In the process of the invention, the admission of the atmosphere is prevented by a liquid salt mixture in the extrusion outlet passage or sprayed on through nozzles. The drawing shows an apparatus for use in drawing metals. The furnace contains a salt bath *A* in which there is a drawing die *B* supported just below the level of the salt melt. The metal blank is situated below the die and its tip is subjected to a tractive force with the aid of drawing jaws through a wire connection. With the aid of the apparatus diagramatically illustrated, a wire 1·5mm in diameter was drawn down in stages of 1/10mm from a thorium blank of a diameter of 3·8mm at a bath temperature of 800 deg. Cent. Shaping was then rapidly and readily effected in drawing stages of 5/100mm. An extrusion tool is also illustrated in the specification.—*August* 4, 1960.

Catalogues and Brochures

PEGLERS, Ltd., Belmont Works, Doncaster.—A comprehensive reference catalogue describing the range of engineers' brasswork produced by the company, covering control fittings on steam, oil, air and water pipe lines. The 412-page book contains much general data, including extracts from British Standard Specifications, temperature and other conversion tables.

WAKEFIELD-DICK INDUSTRIAL OILS, Ltd., Castrol House, Marylebone Road, London, N.W.1.—A seventy-four-page illustrated handbook dealing with the design, installation, operation and maintenance of hydraulic equipment. Chapters are included on "Historical Development," "Fundamental Hydraulic Principles," "Hydraulic Pumps and Motors," "Components of Hydraulic Circuits," and "Hydraulic Fluids."

MORGAN REFRACTORIES, Ltd., Battersea Church Road, London, S.W.11.—Literature giving technical details of "Tri-Mor" mouldable and castable refractories, also a leaflet describing "Morganite" carbon for the glass industry.

SIMON-CARVES, Ltd., Cheadle Heath, Stockport.—Folder describing the "Otto" continuous catalytic reforming process for the production of town's gas and synthesis gas from hydrocarbon feedstocks. Simon-Carves, Ltd., is the sole licensee for the "Otto" process in the United Kingdom.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BIRMINGHAM SCIENCE MUSEUM

Thurs., Sept. 29.—Museum of Science and Industry, Newhall Street, Birmingham, 3, "Live Steam Operation of Five Engines," evening until 9 p.m., additional to regular "Steam Week-ends."

BRITISH INTERPLANETARY SOCIETY

Thurs., Sept. 1.—Manson House, 26, Portland Place, London, W.1, One-day Joint Symposium with the Society of Instrument Technology, on "Rocket and Satellite Instrumentation," 10.30 a.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Sept. 6.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "Pneumatic Transfer Machinery and Circuitry," D. C. Evans, 7 p.m.

Wed., Sept. 7.—EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, "The History of Boilers," W. Renton, and "An Engineer and the Carpet Industry," W. Geekie, 7 p.m. * LEICESTER BRANCH : Saracen's Head Hotel, Leicester, Film and Discussion "On Schedule," F. W. L. Heathcote, 7 p.m.

Thurs., Sept. 8.—GLASGOW BRANCH : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, "Factory Fire Alarm Systems," W. Roby, and R. S. C. Dougall, 7.15 p.m. * NORTH EAST BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, 1, "Electrical Power Distribution," J. E. Finn, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Tues., Aug. 30 *to Sat., Sept.* 3.—The University College of North Wales, Bangor, Annual Conference, 1960.

Advanced Engineering Courses

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Management Appreciation : Course in Work Study. LOUGHBOROUGH COLLEGE OF TECHNOLOGY, Loughborough, Leicestershire. A two-day course, September 21 and 22, designed to enable directors and general managers to obtain a quick introduction to the contents of succeeding courses, in order to assess their value and to make the fullest use of members of their staff who have followed, or are to follow, a main course. Fee, tuition £5, residence £3.

Automatic Control and its Application to Mechanical Engineering. BOROUGH POLYTECHNIC, Borough Road, London, S.E.1. A course of eight lectures arranged for Tuesday evenings at 7 p.m. commencing on October 11. These lectures are intended for practising engineers who are interested in the use of automatic control methods and their current industrial applications.

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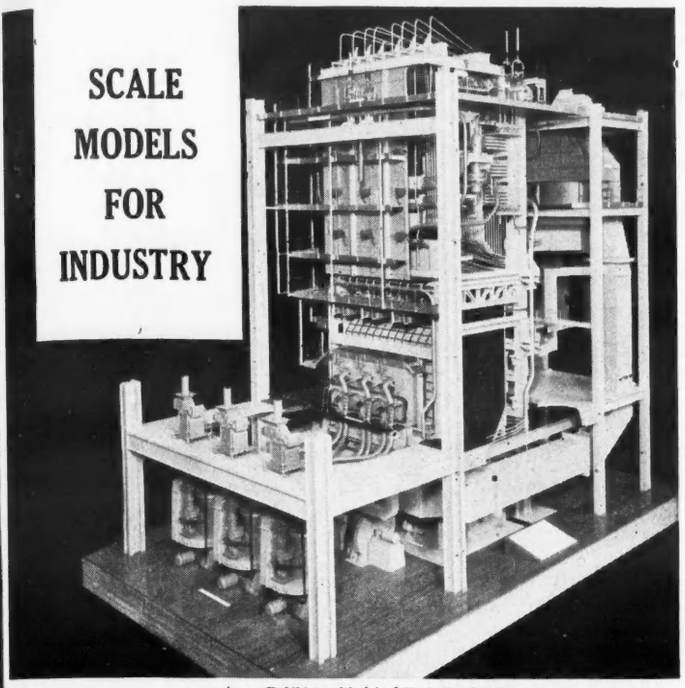

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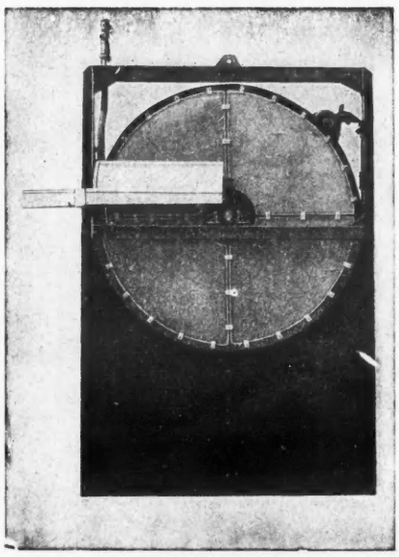

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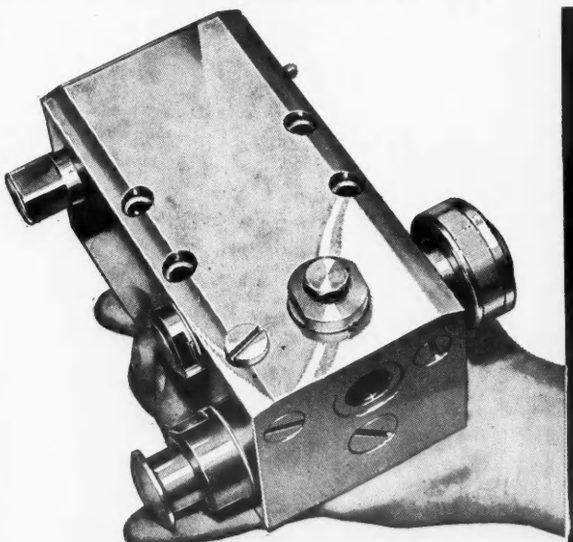

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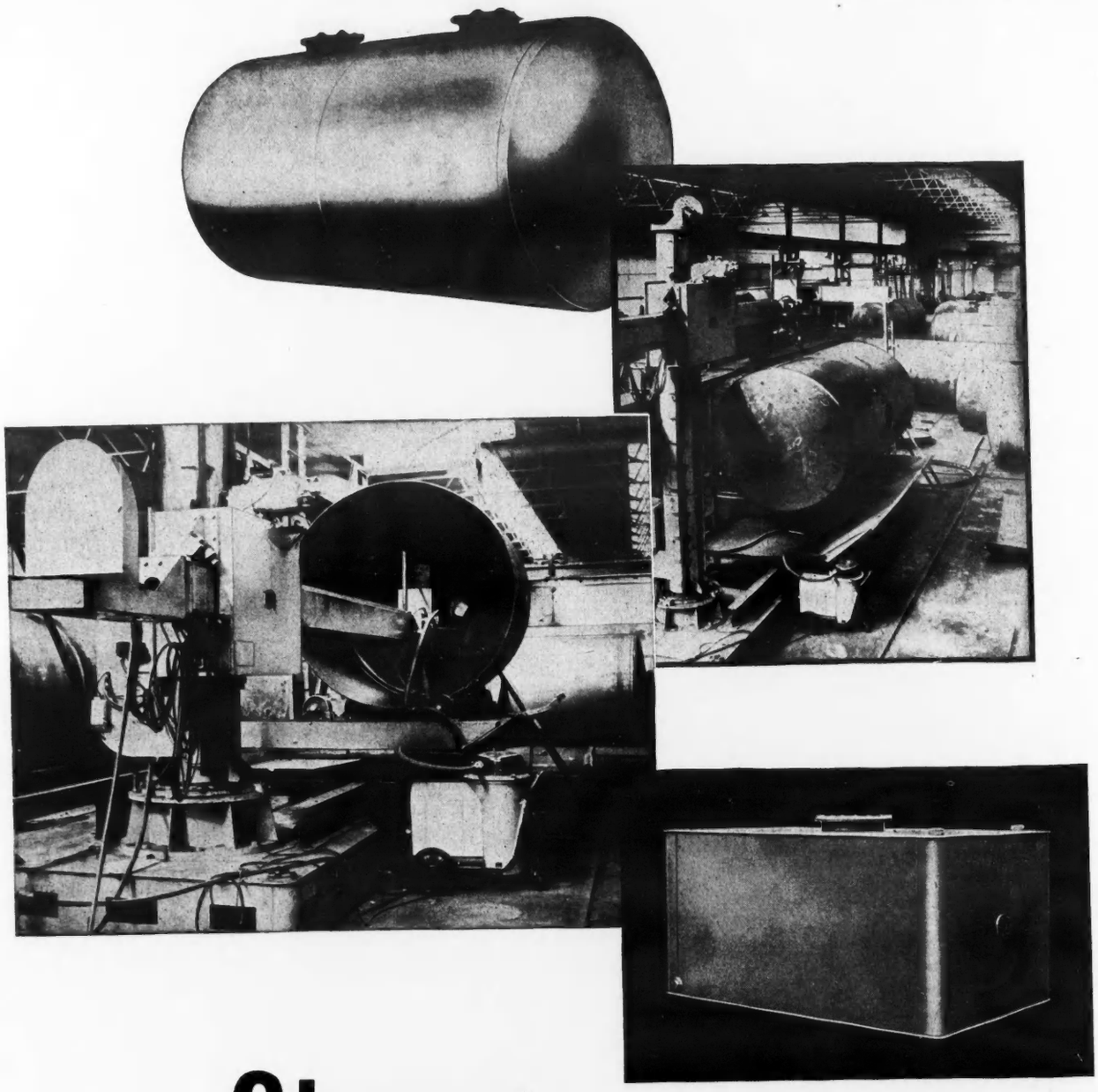

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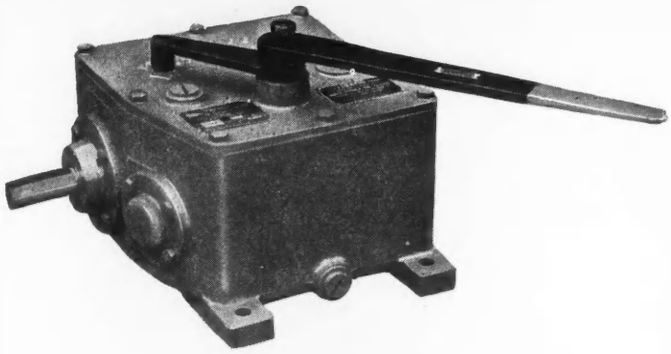

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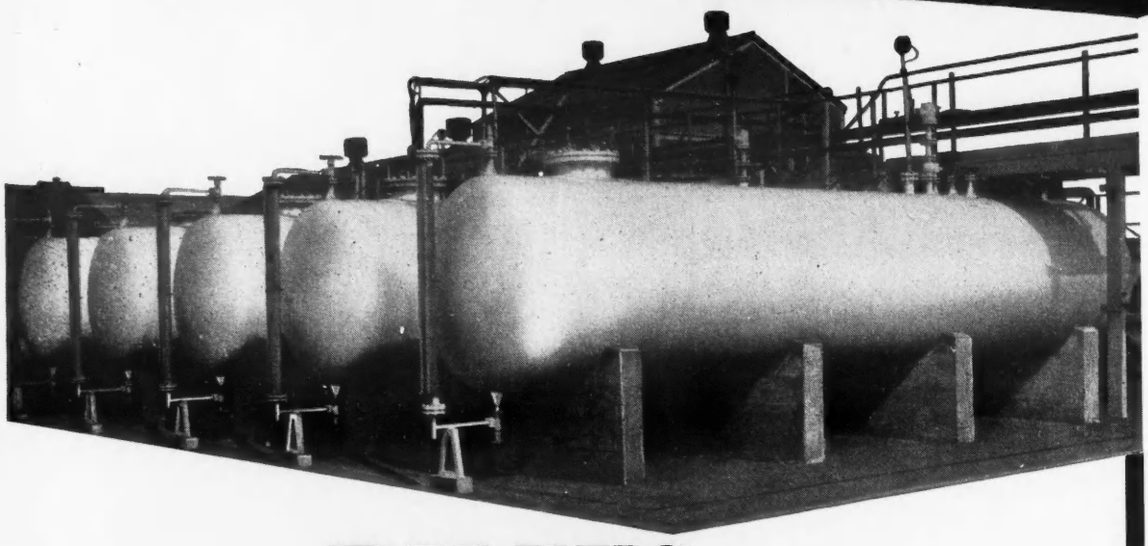

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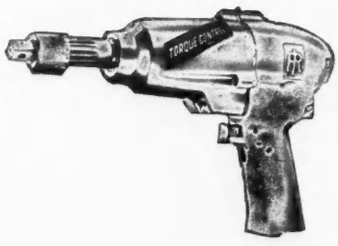

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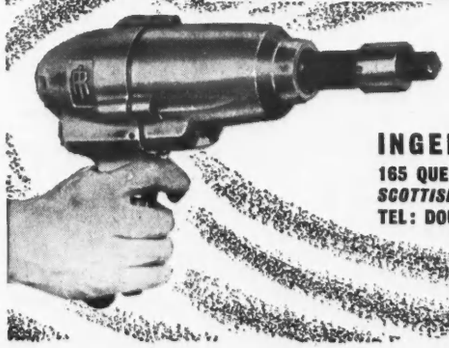

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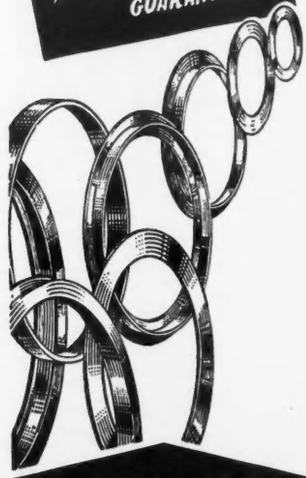

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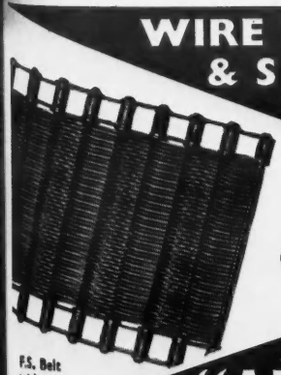

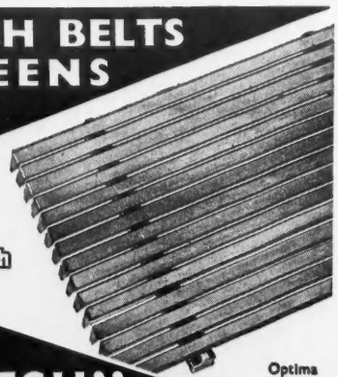

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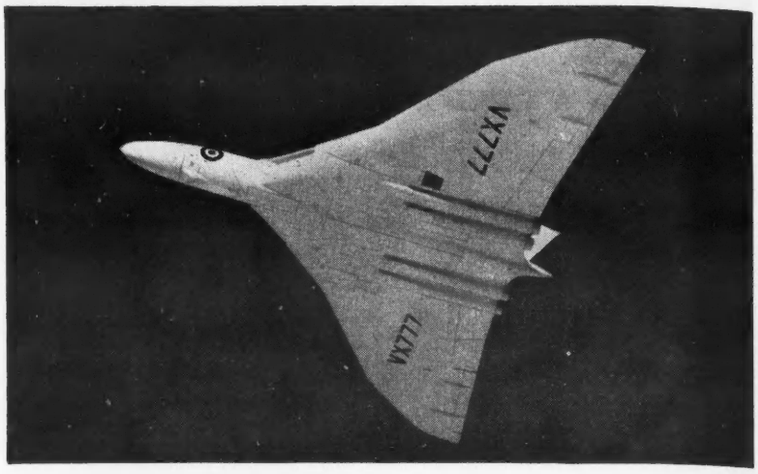

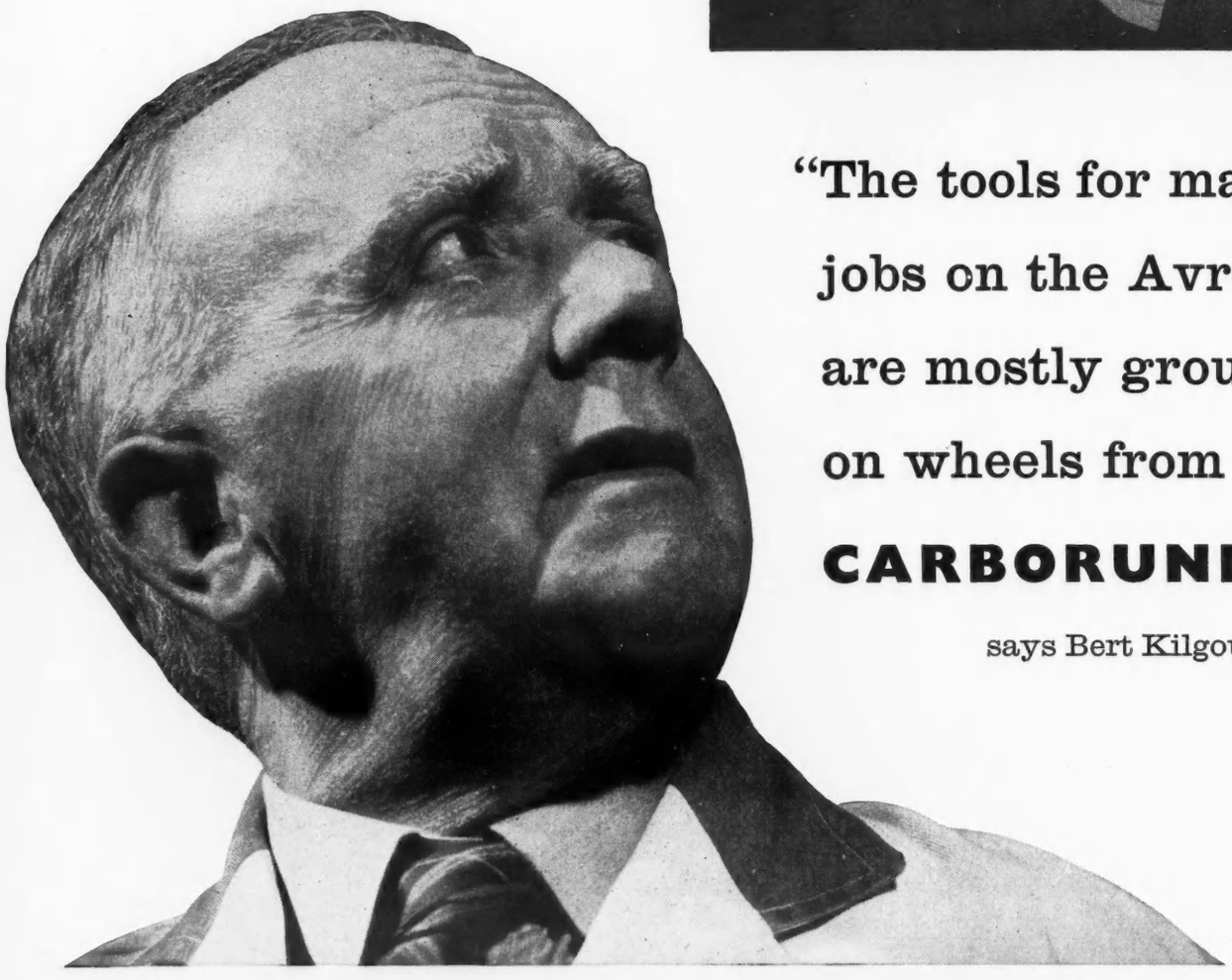

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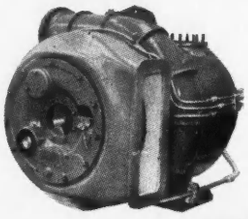

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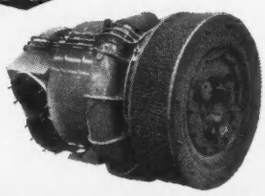

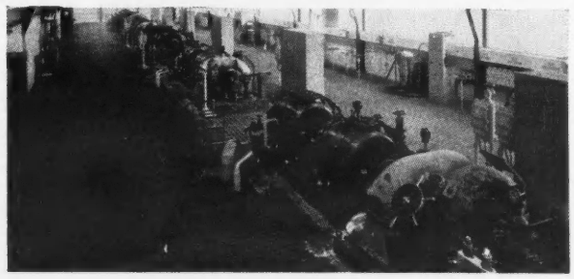

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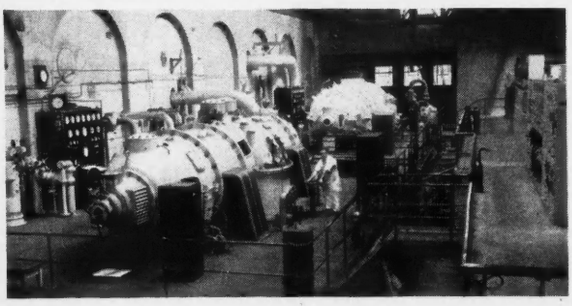

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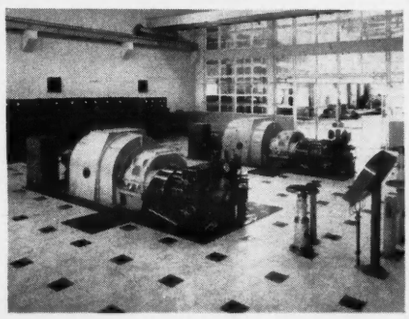

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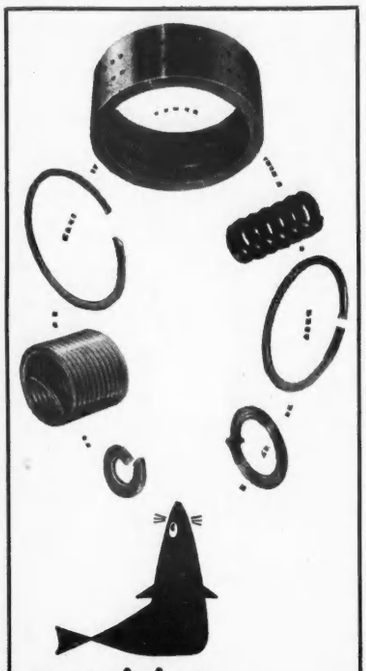

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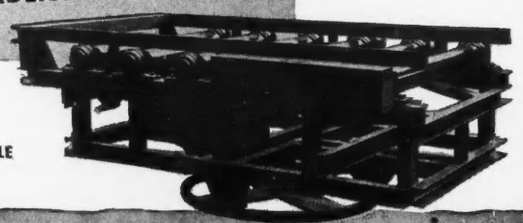

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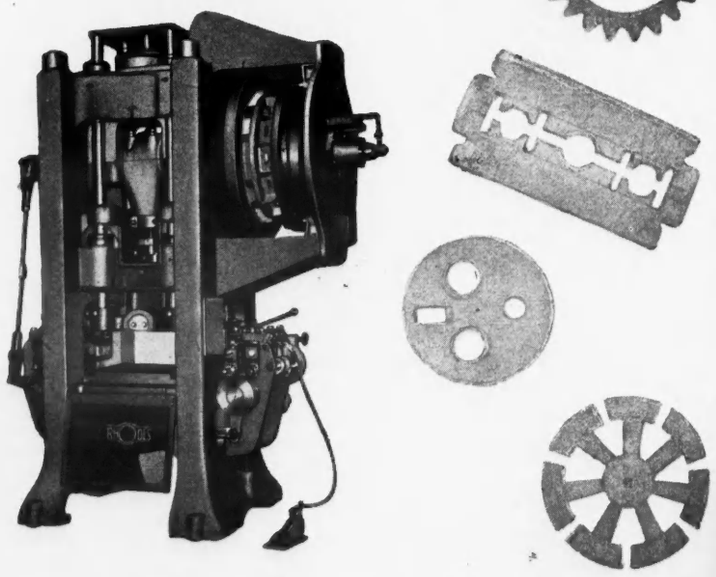

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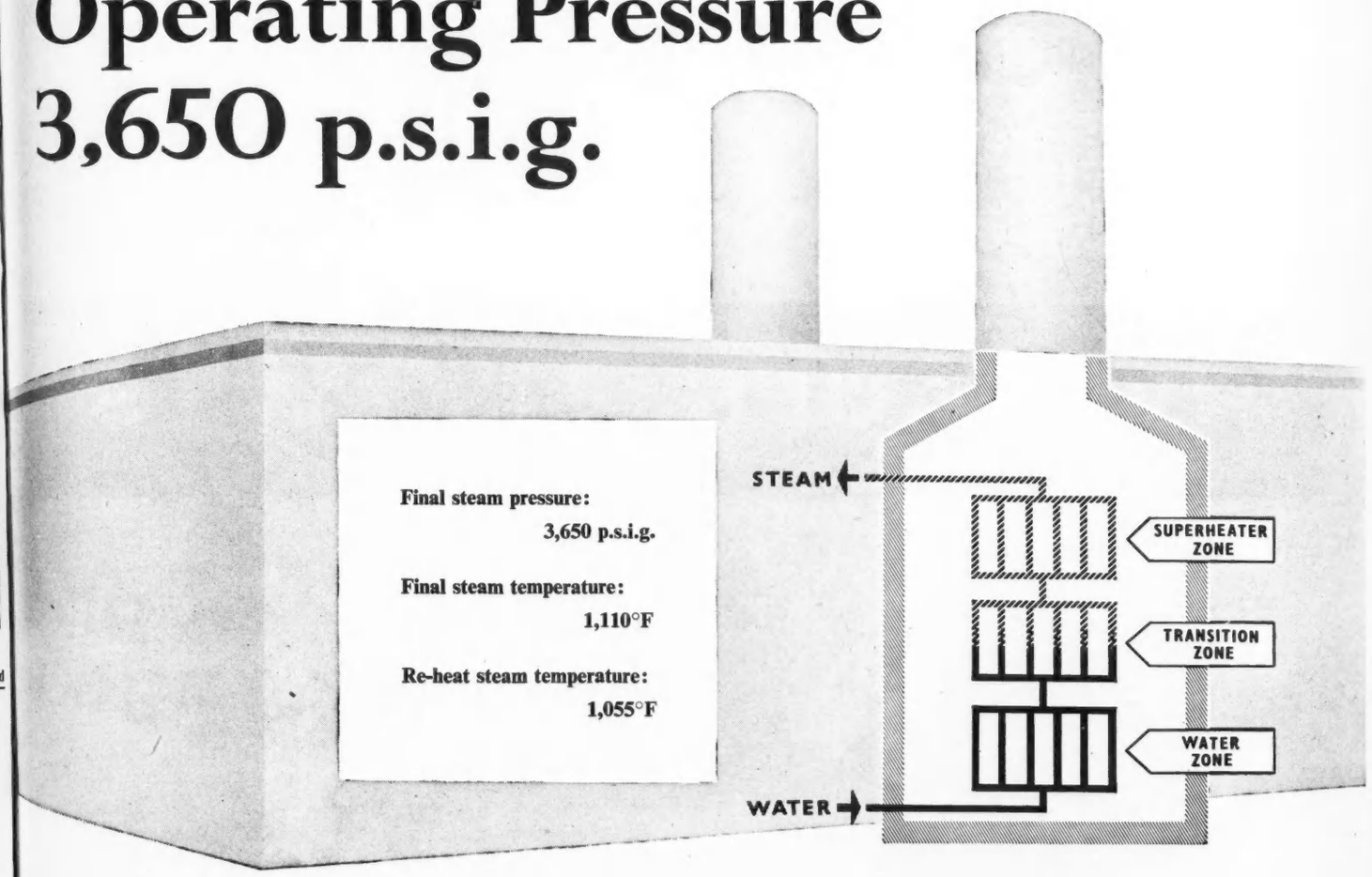

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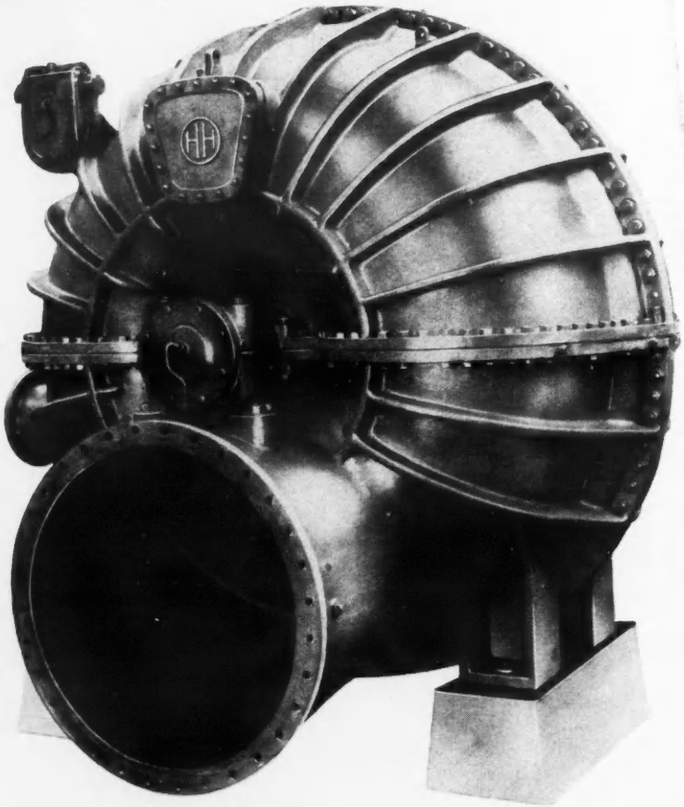

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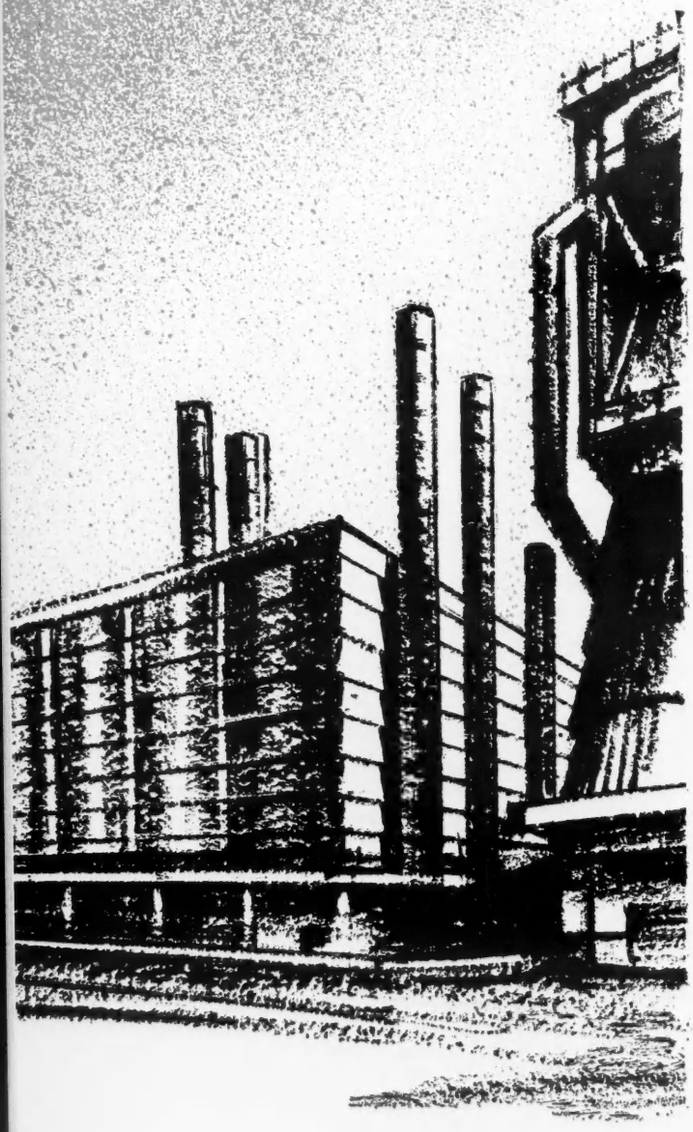

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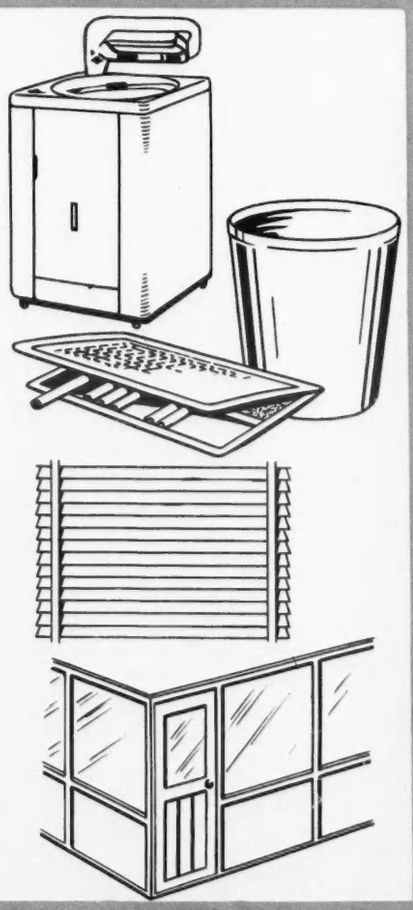

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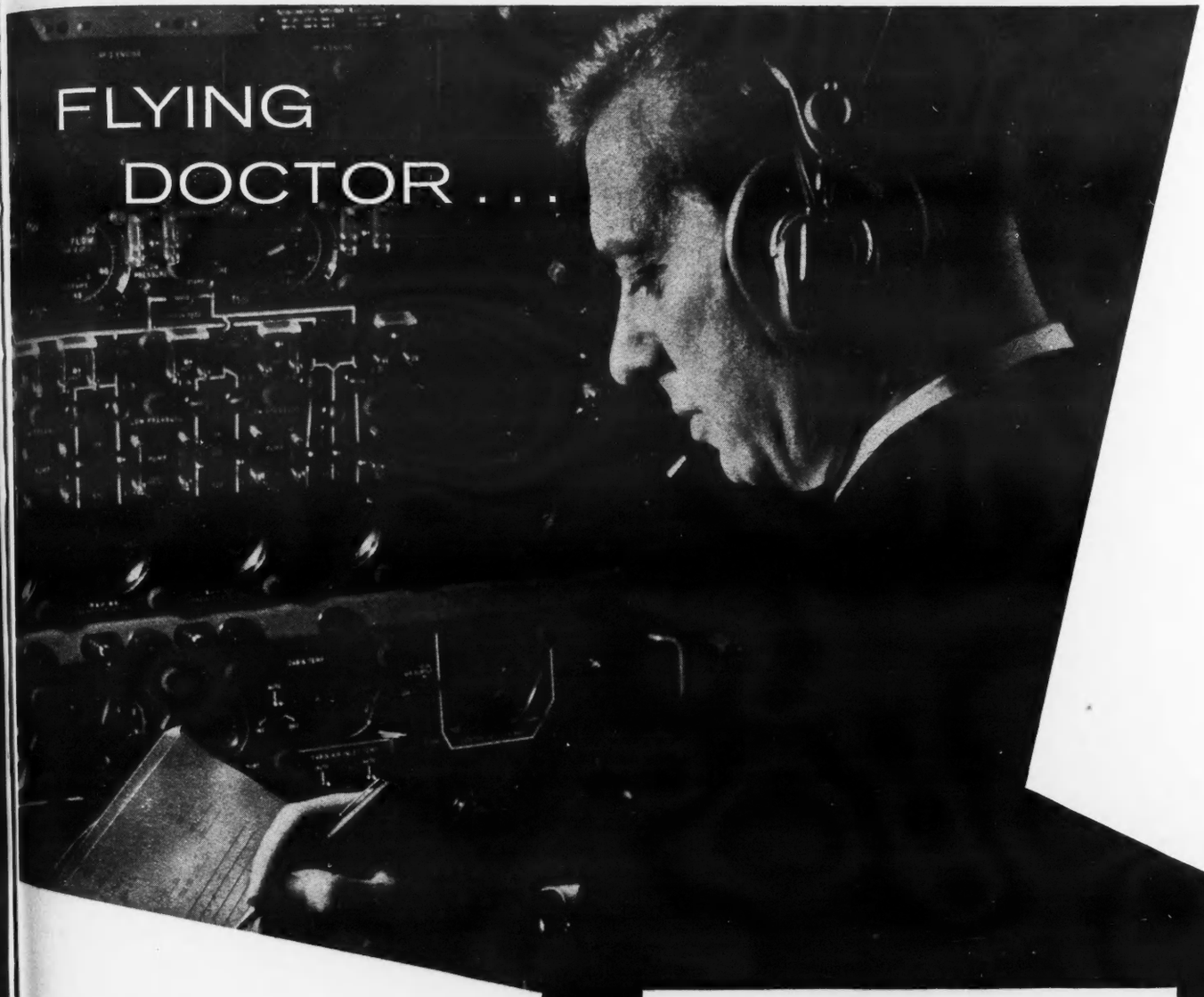

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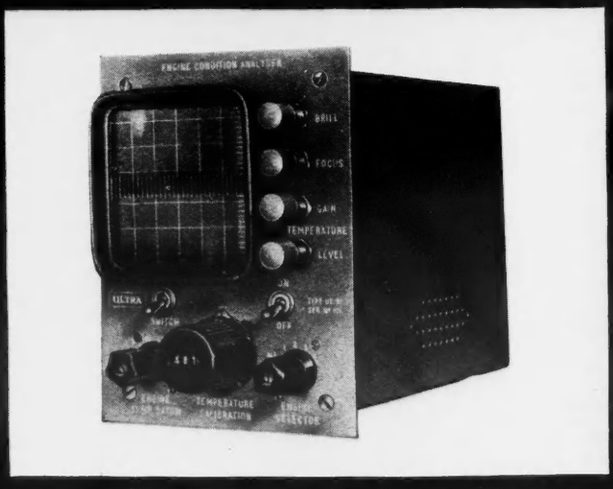

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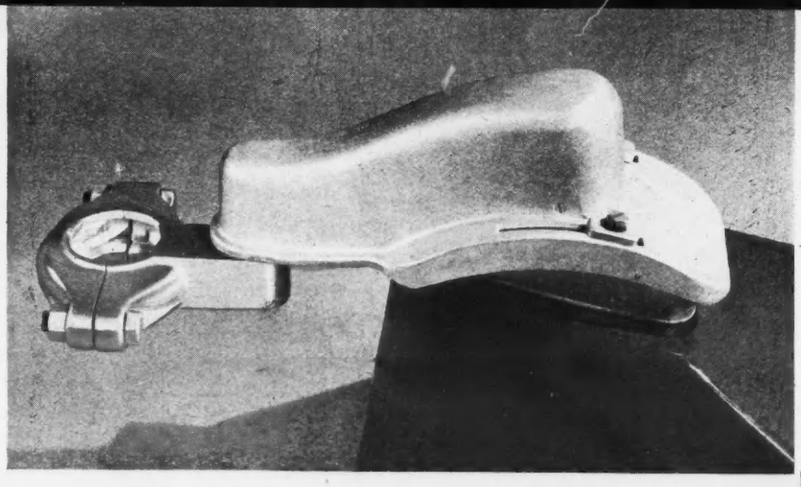

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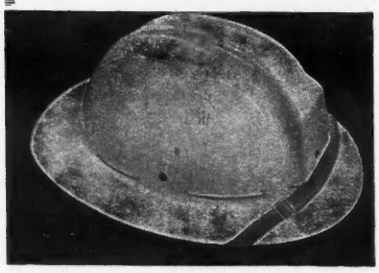

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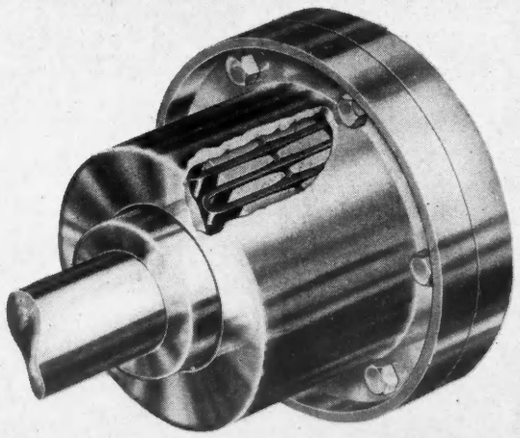

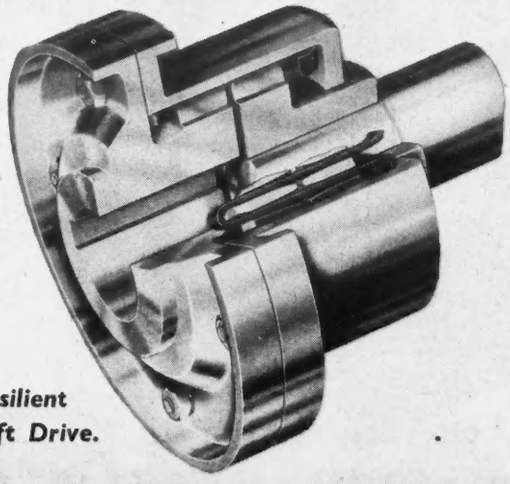

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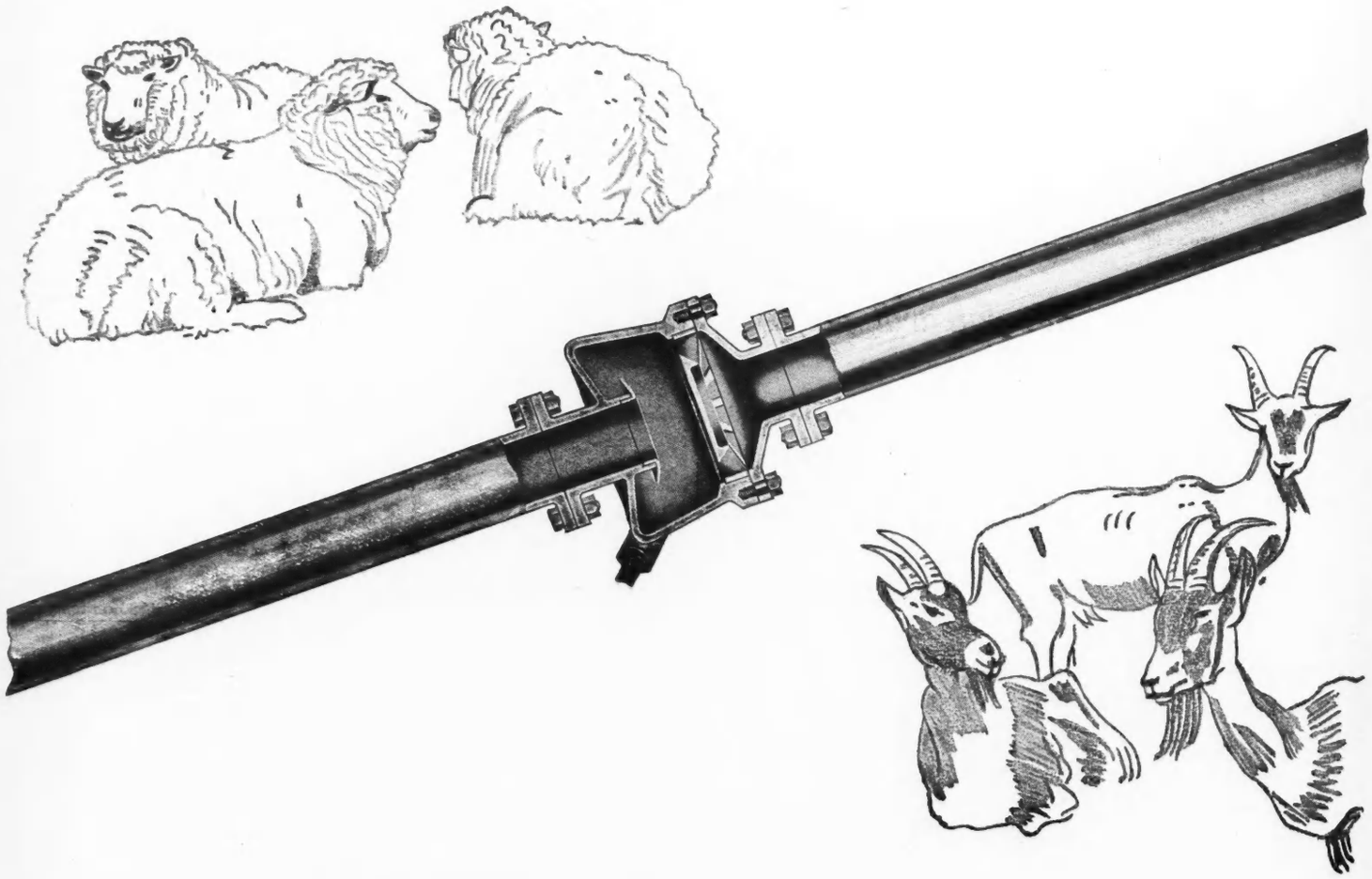

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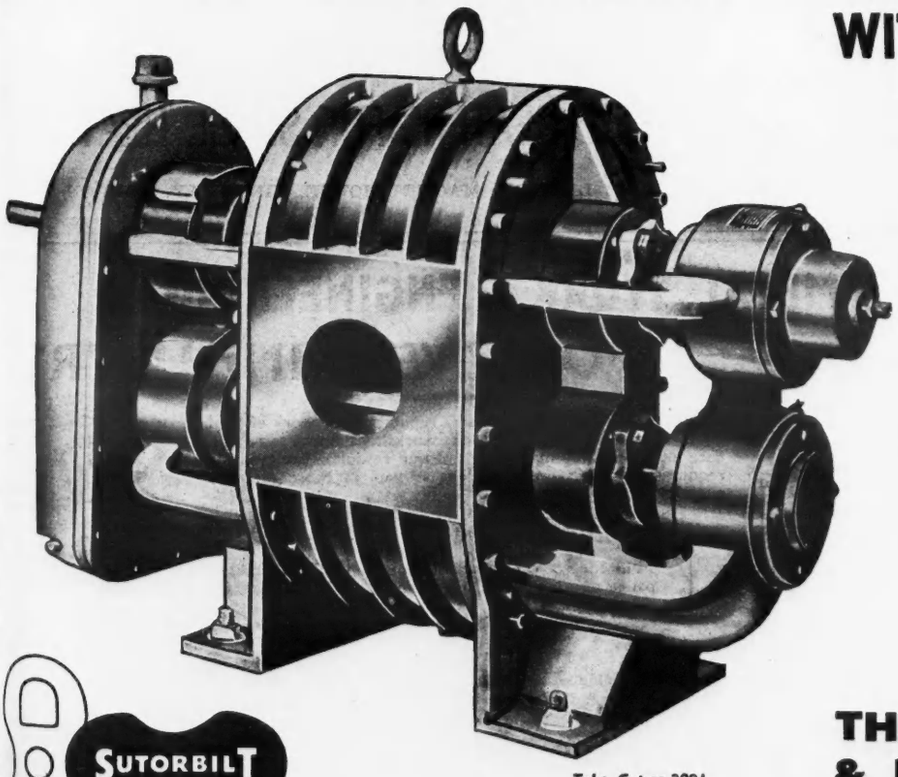

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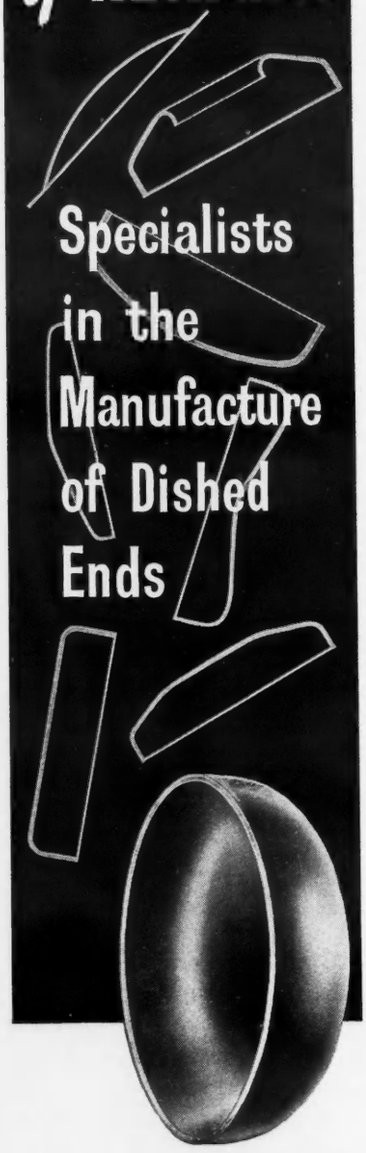

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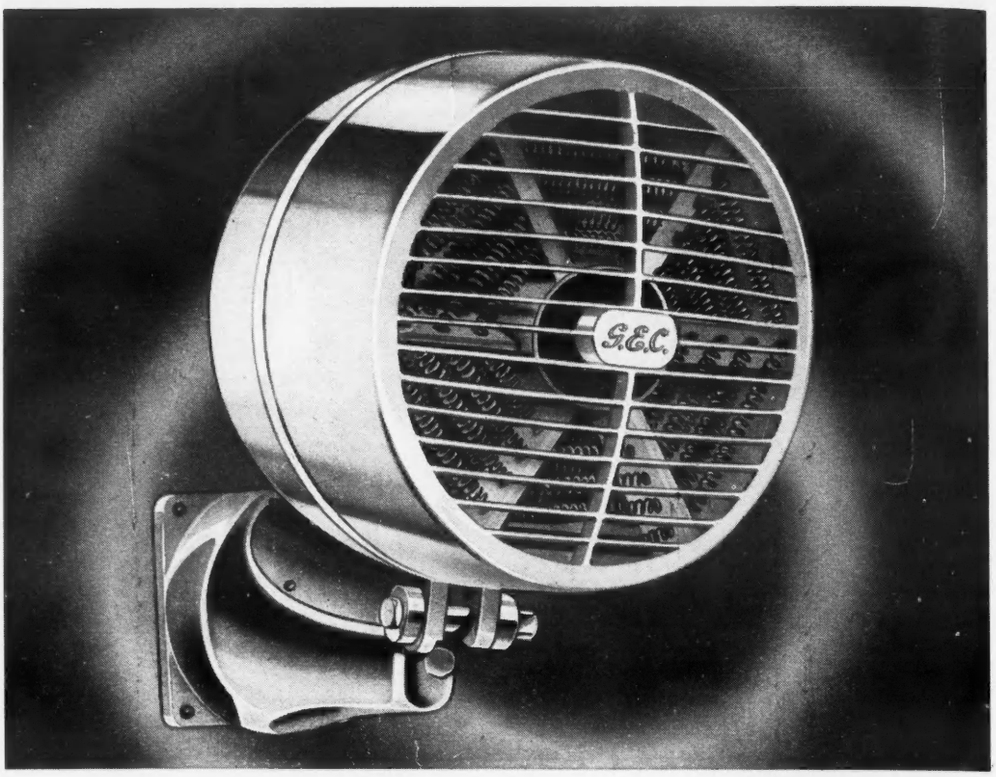

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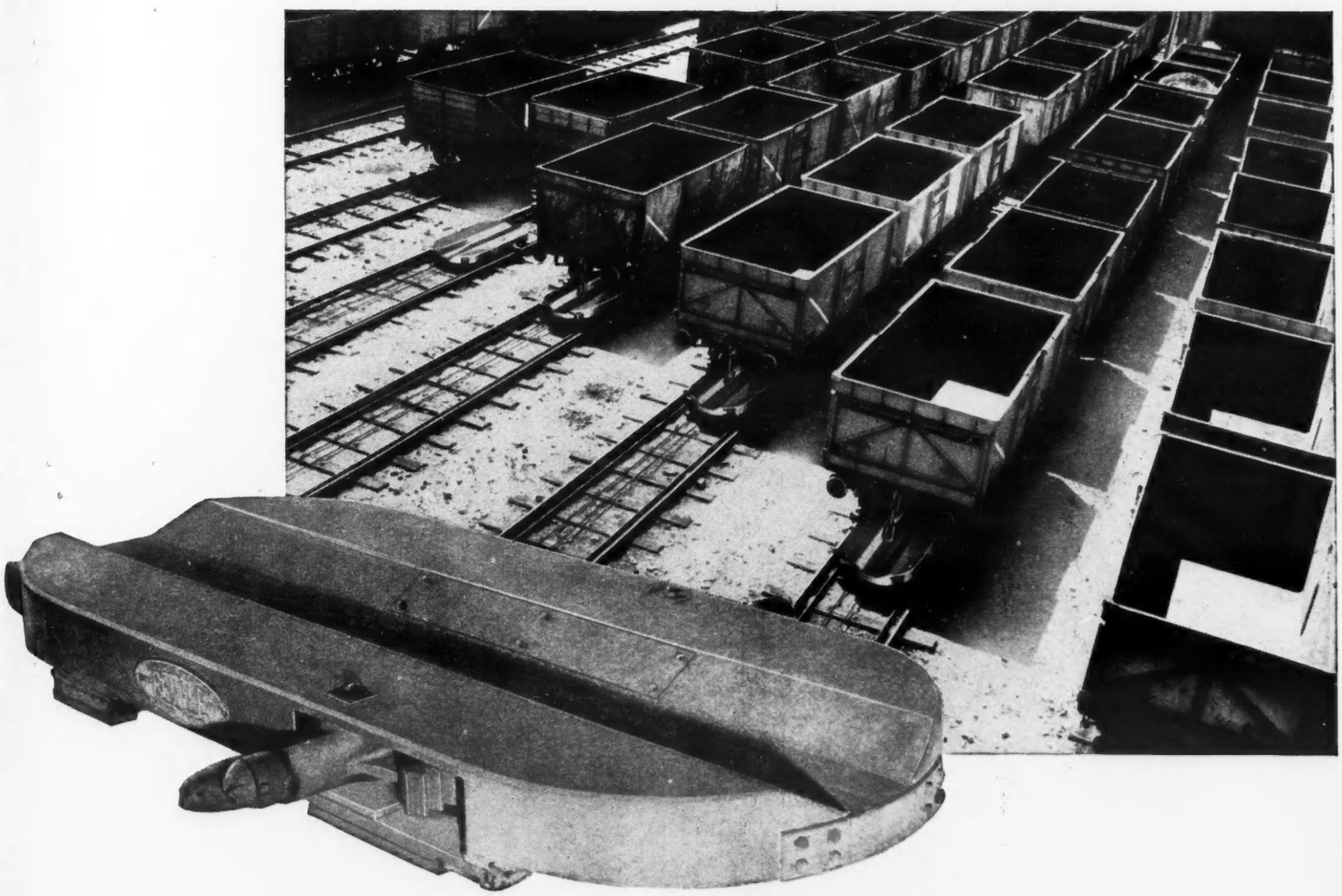

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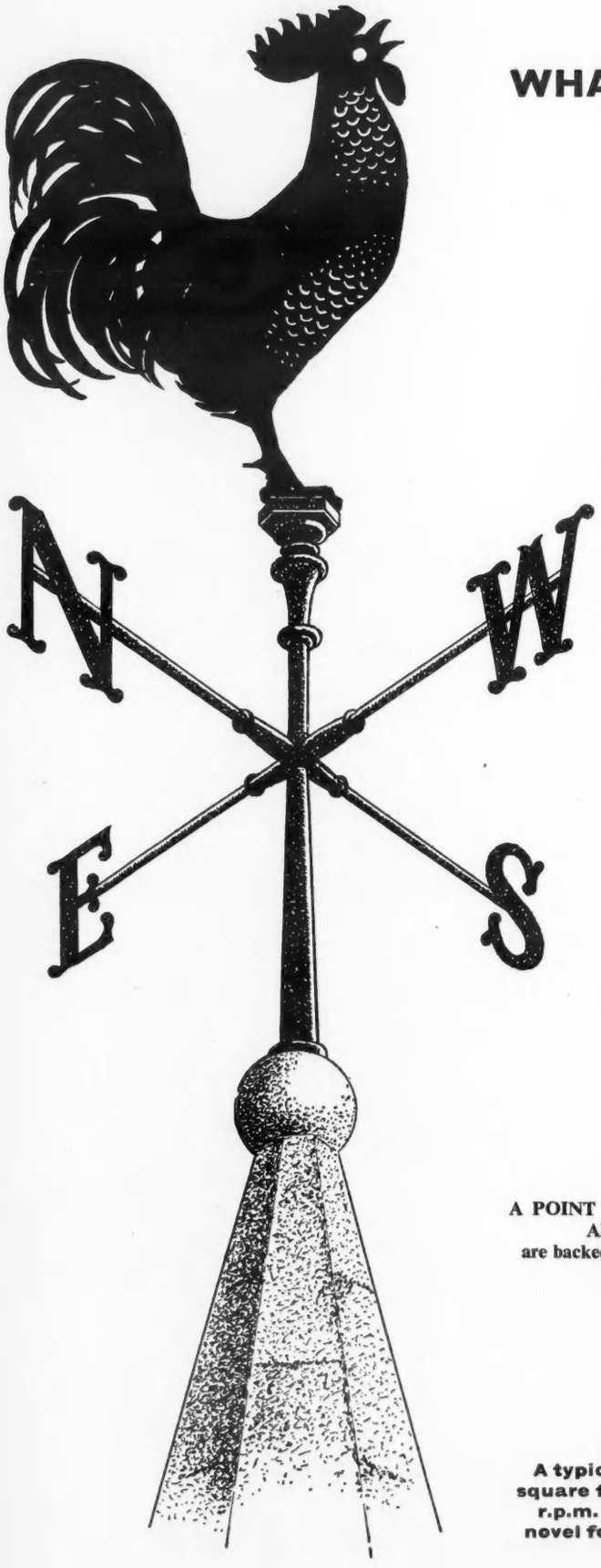

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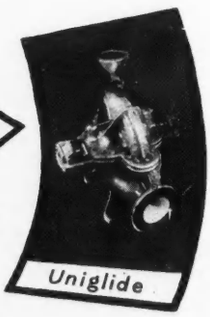

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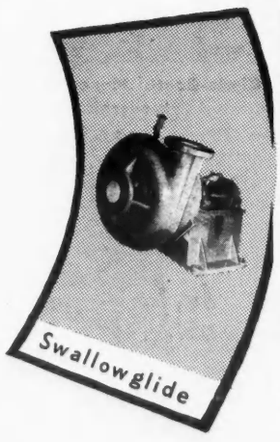

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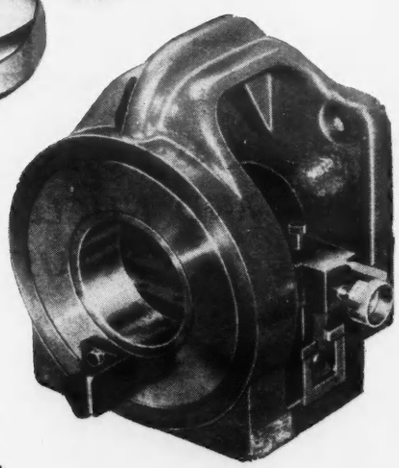

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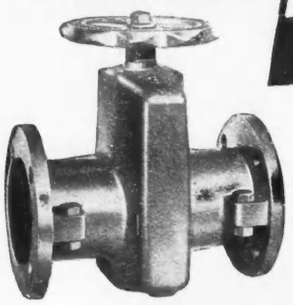

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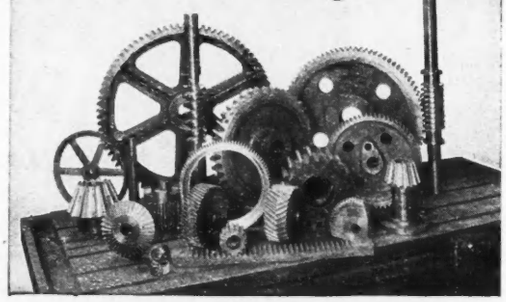

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FOR MODERN SHIPYARDS

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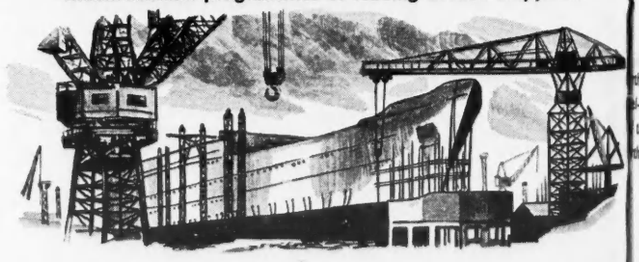

The 35 tons capacity crane illustrated is installed at the Hebburn yard Messrs. Hawthorn Leslie (Shipbuilders) Ltd., by whose kind permission this photograph is reproduced.

These semi-level luffing cranes are ideally suited to the contemporary trend towards construction in larger prefabricated sections.

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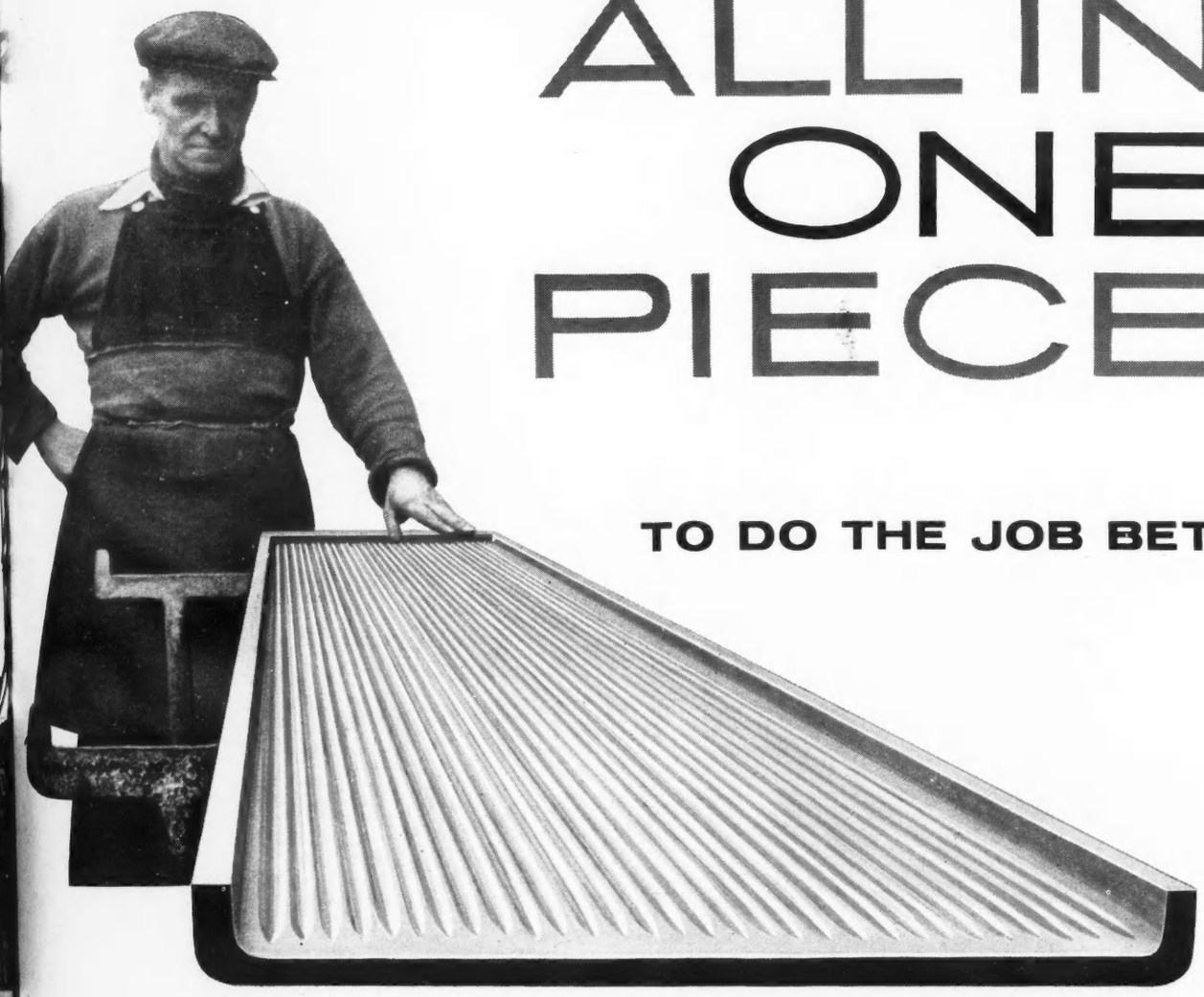

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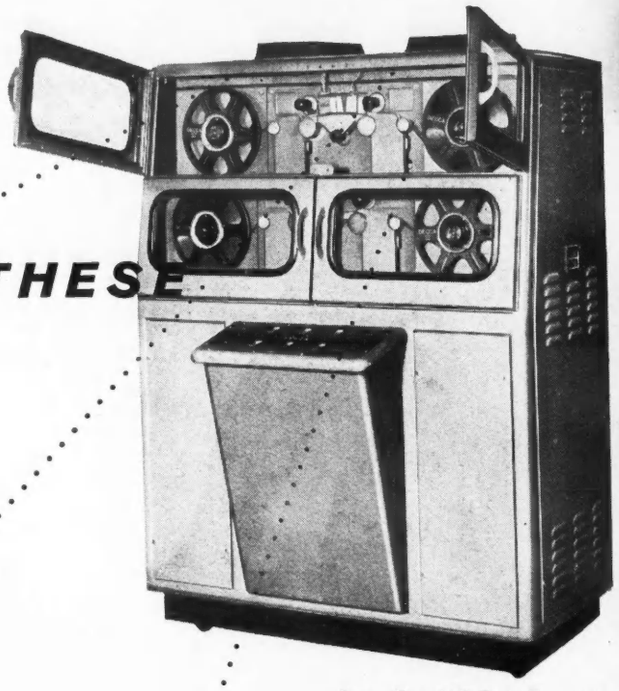
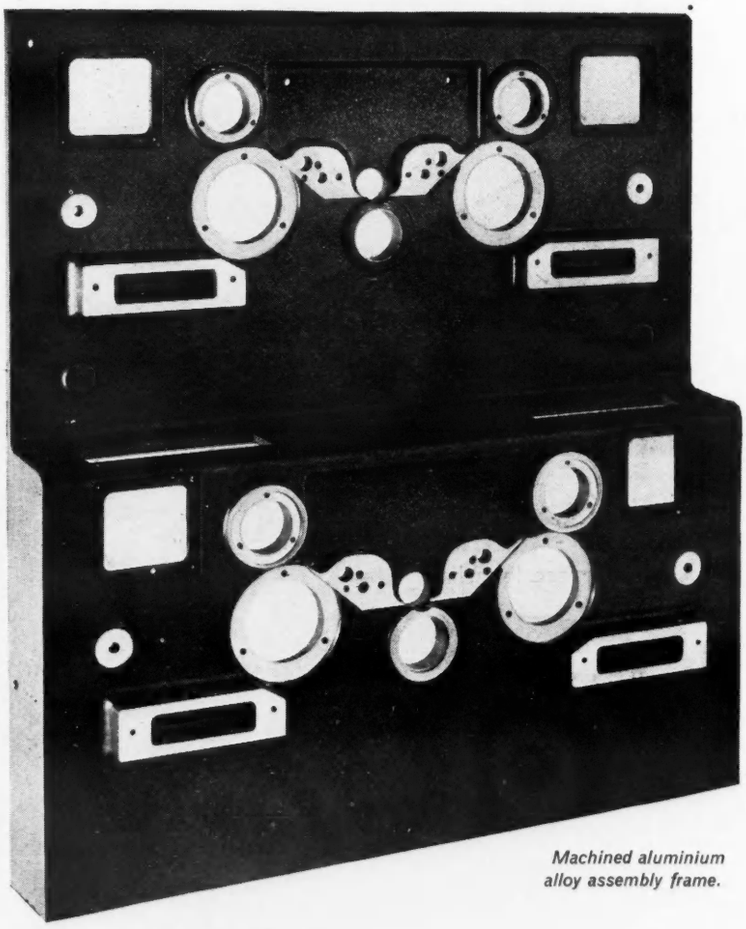


Decca Type 3000 Twin Tape Unit



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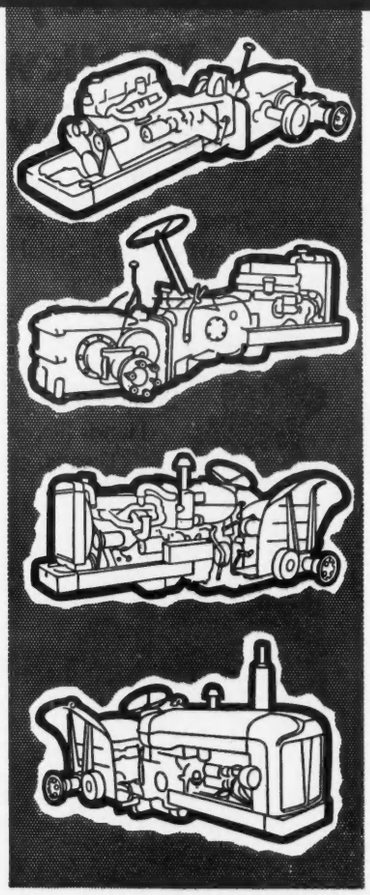

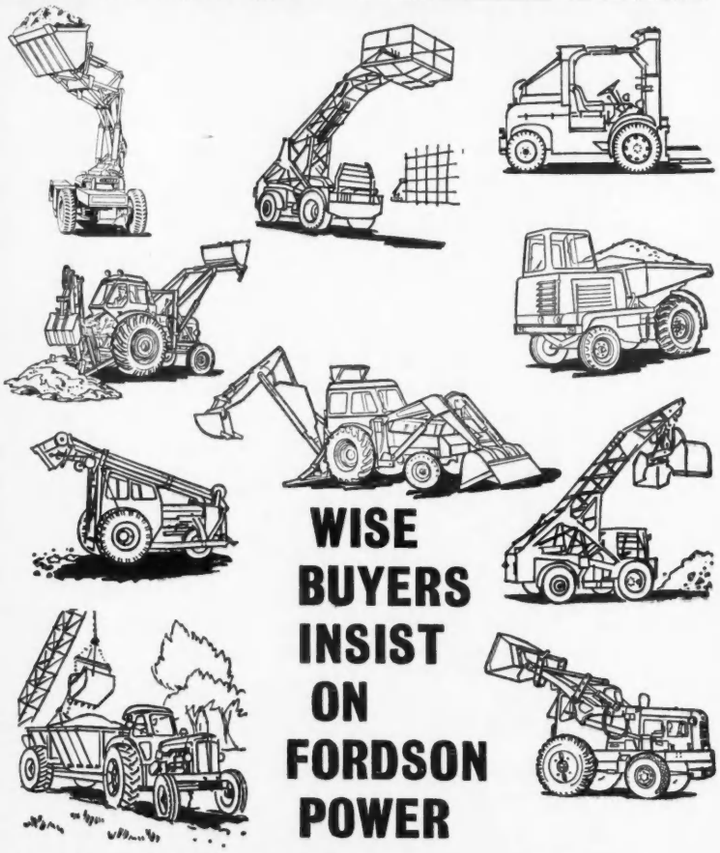

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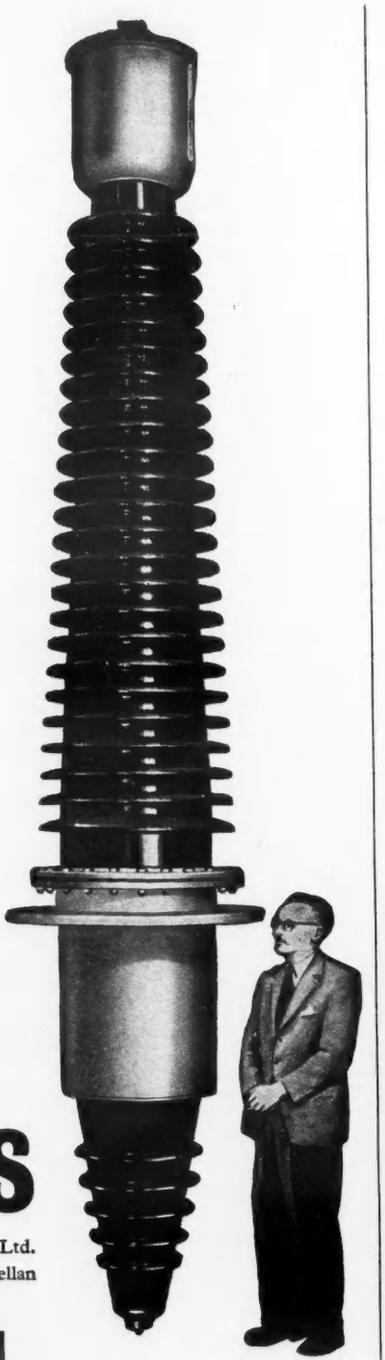
KARIBA at 330 kV.



All the bushing porcelains for
the 330 kV. circuit breakers
All the 330 kV. strain insulators
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and the 330 kV. post insulators
for some of the substations by

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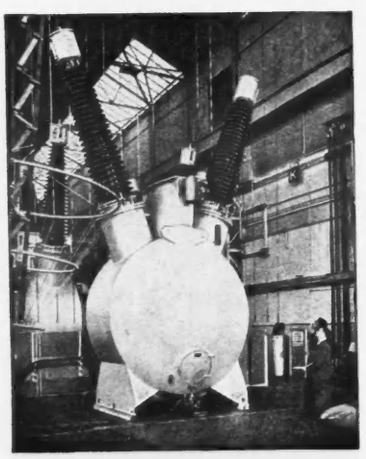

The illustrations show a complete 330 kV. bushing insulator and a 330 kV. circuit breaker, by courtesy of the B.T.H. Co.

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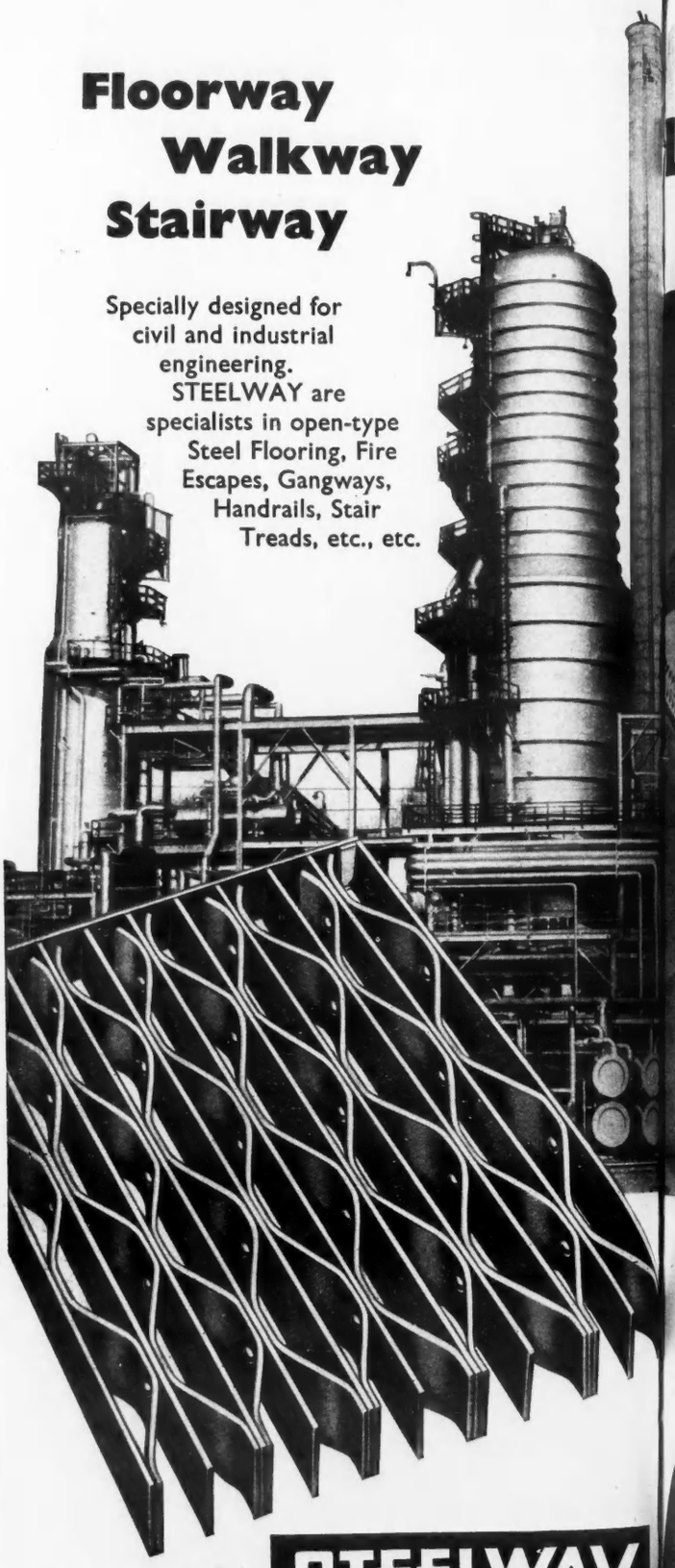

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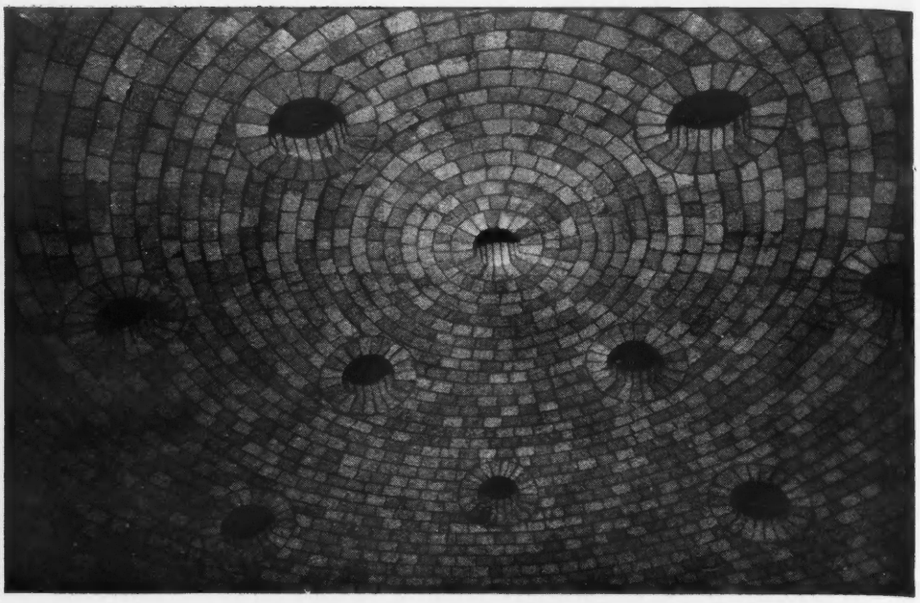

Five years ago we began rebuilding the round down-draught kilns of the Morgan Crucible Co. Ltd. at Battersea in MI.28—a hot-face insulating brick of low thermal capacity that was then comparatively new. The roof of one of these furnaces immediately after installation is shown in the first picture.

. . .(MI. 28 bricks)

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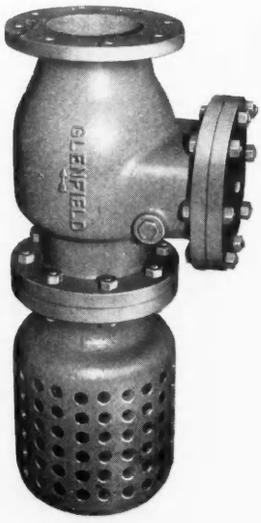

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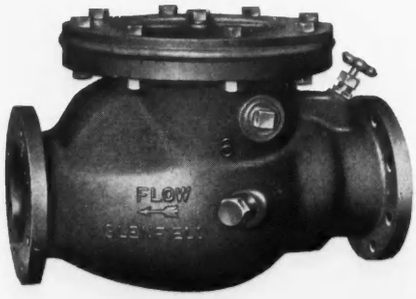

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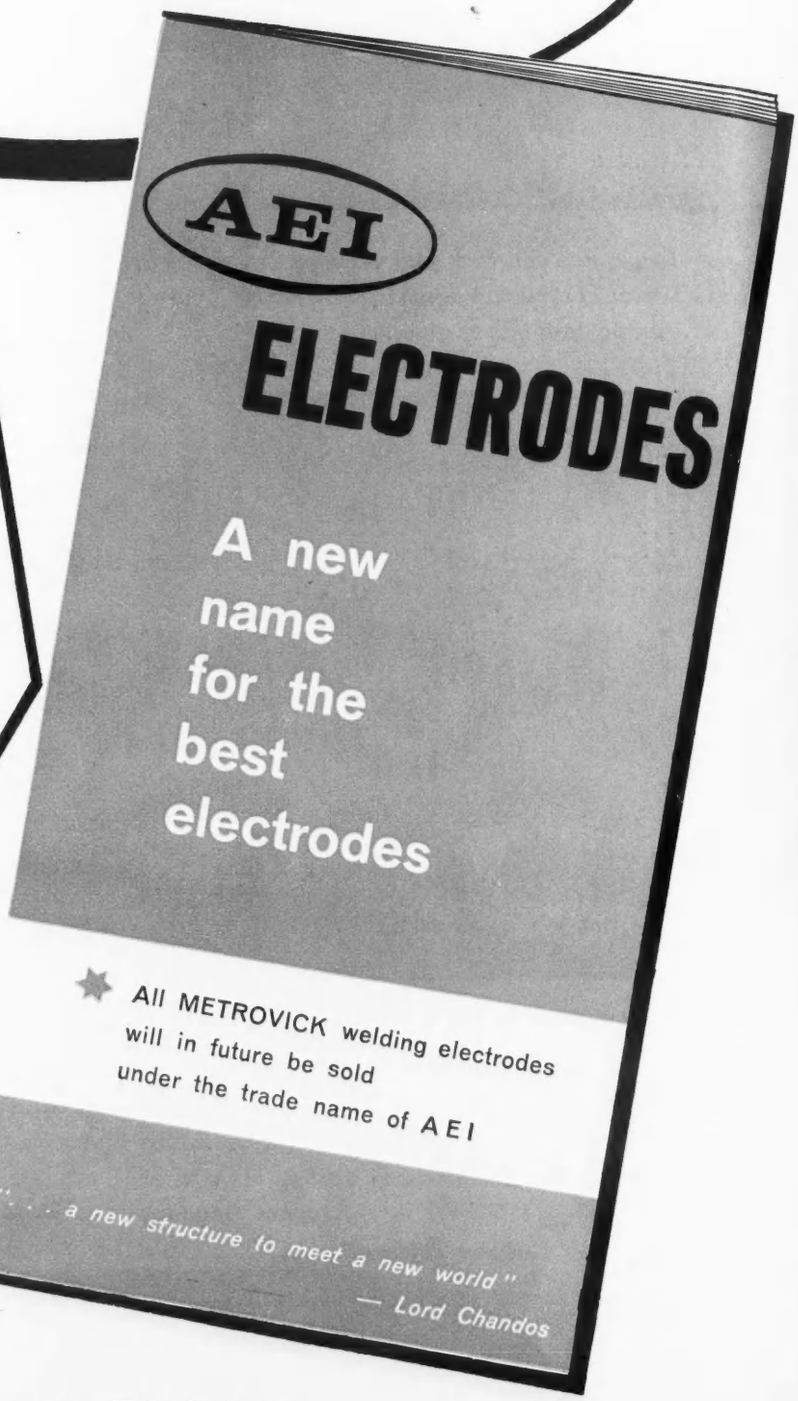
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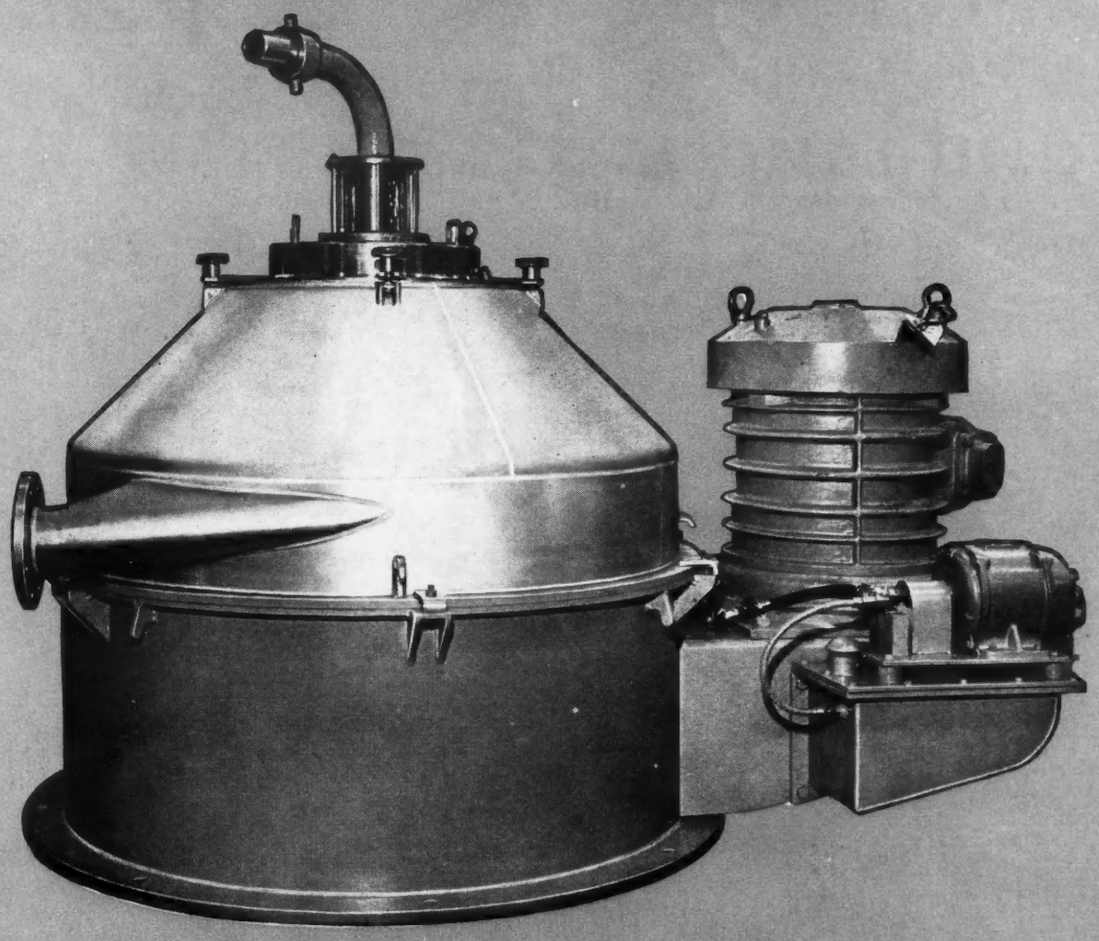

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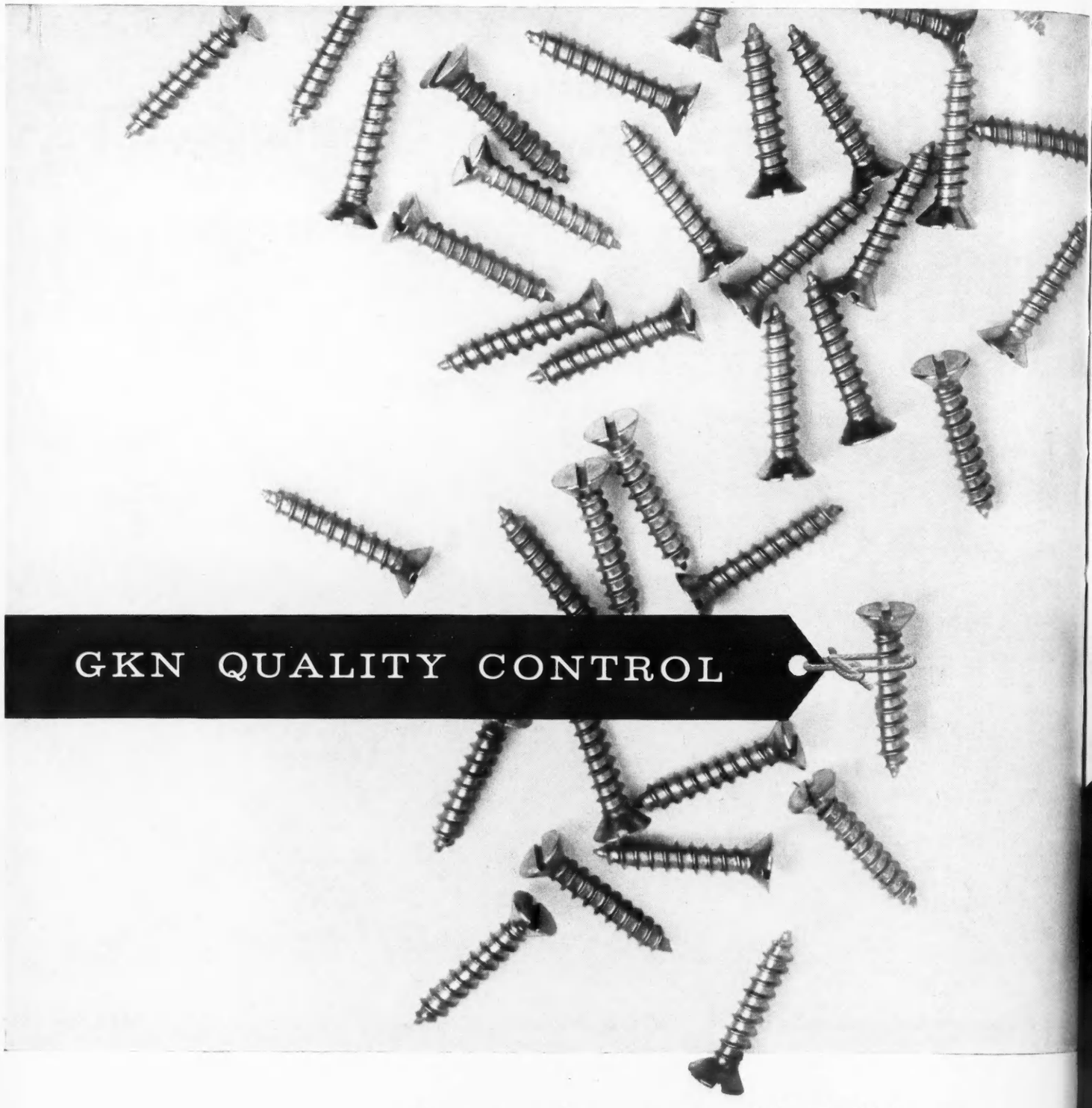

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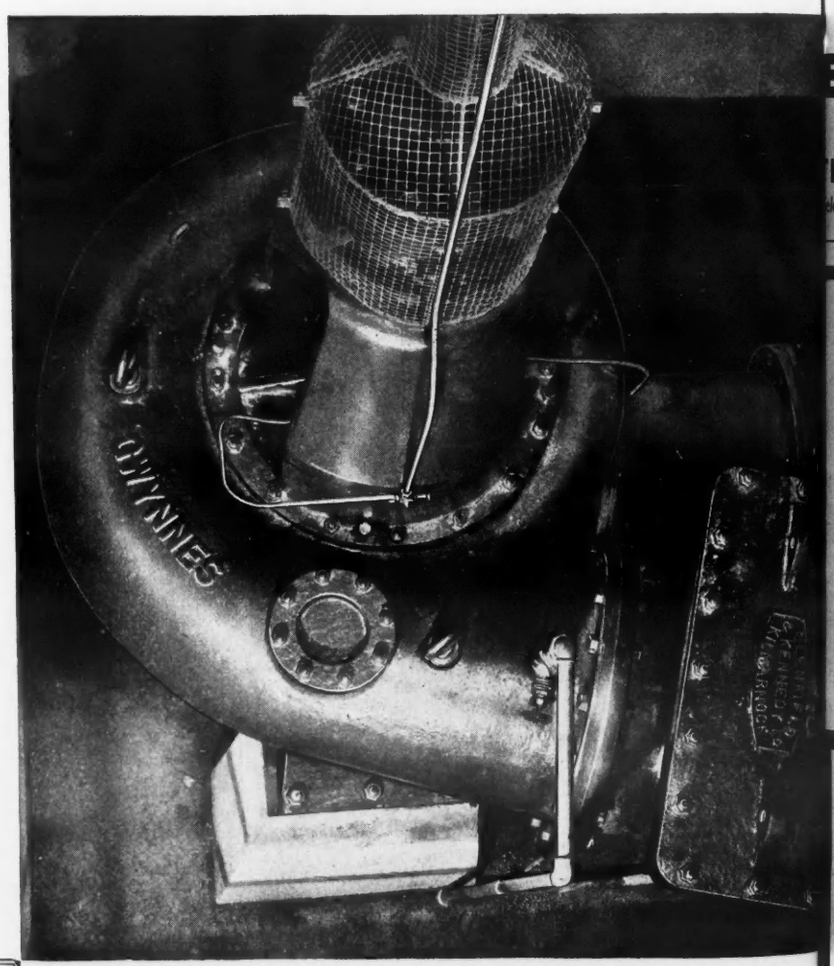

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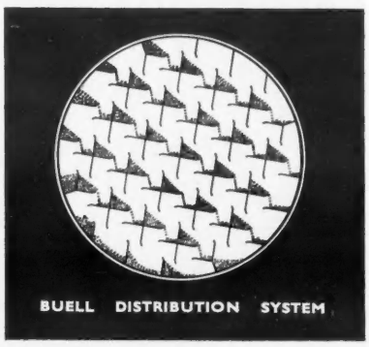
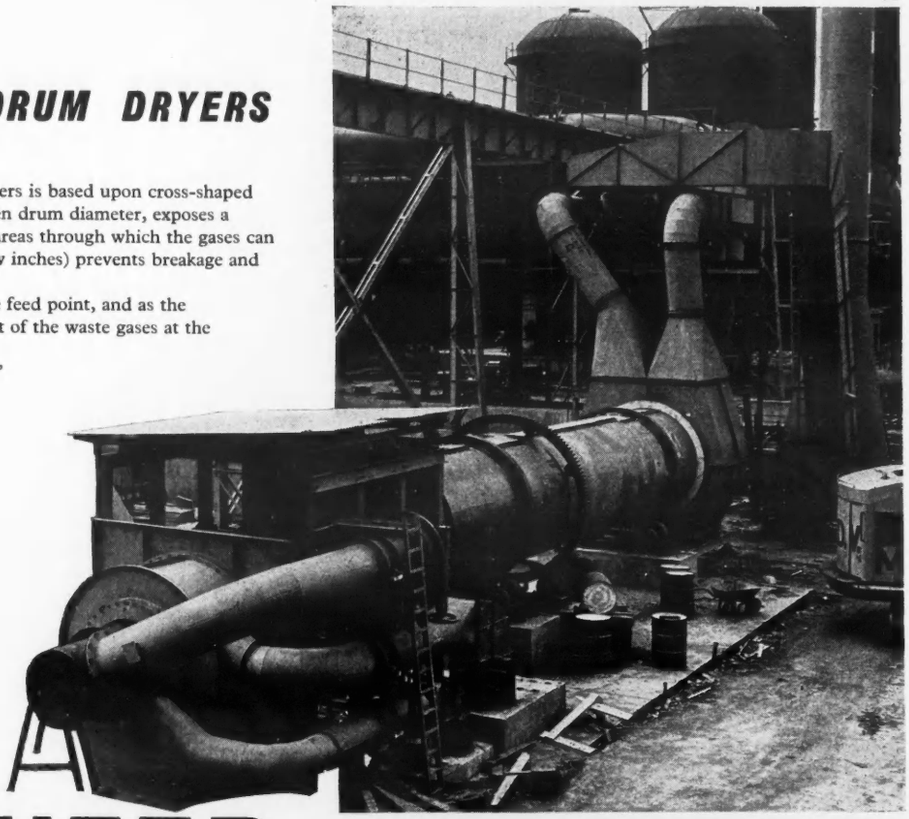
Full particulars in our publication "Drying Equipment."





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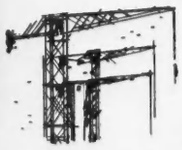
crane collision *WARNING* systems

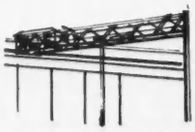


Type 144 TOWER CRANE PROXIMITY GUARD

The proximity guard gives an audible warning or can operate automatic trip circuits whenever crane structures approach closer than the safety requirement permits.

The visual indicator illustrated is fitted in one of two cranes and provides a continuous indication of the relative position of the two cranes.

The system may be adapted to protect other structures with slewing or elevating jibs, rotary or translational motion, providing only that these follow fixed paths, e.g. rail tracks.



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A new, simple, easily installed, yet foolproof system which is based on well tried components.

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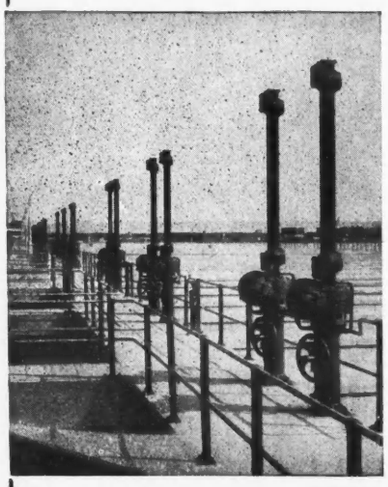

The photograph shows a series of **No. 3 Valectrics** *installed at I.C.C. Northern Outfall Sewage Works, Beckton. (Chief Engineer: J. Rawlinson, C.B.E.)*

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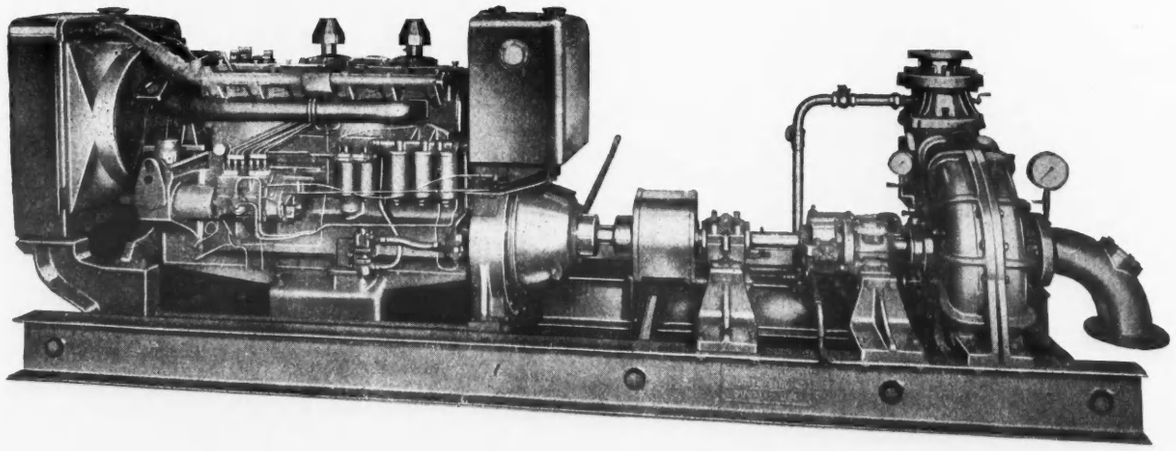

6 Inch Centrifugal Sand and Gravel Pump with Diesel Engine Drive

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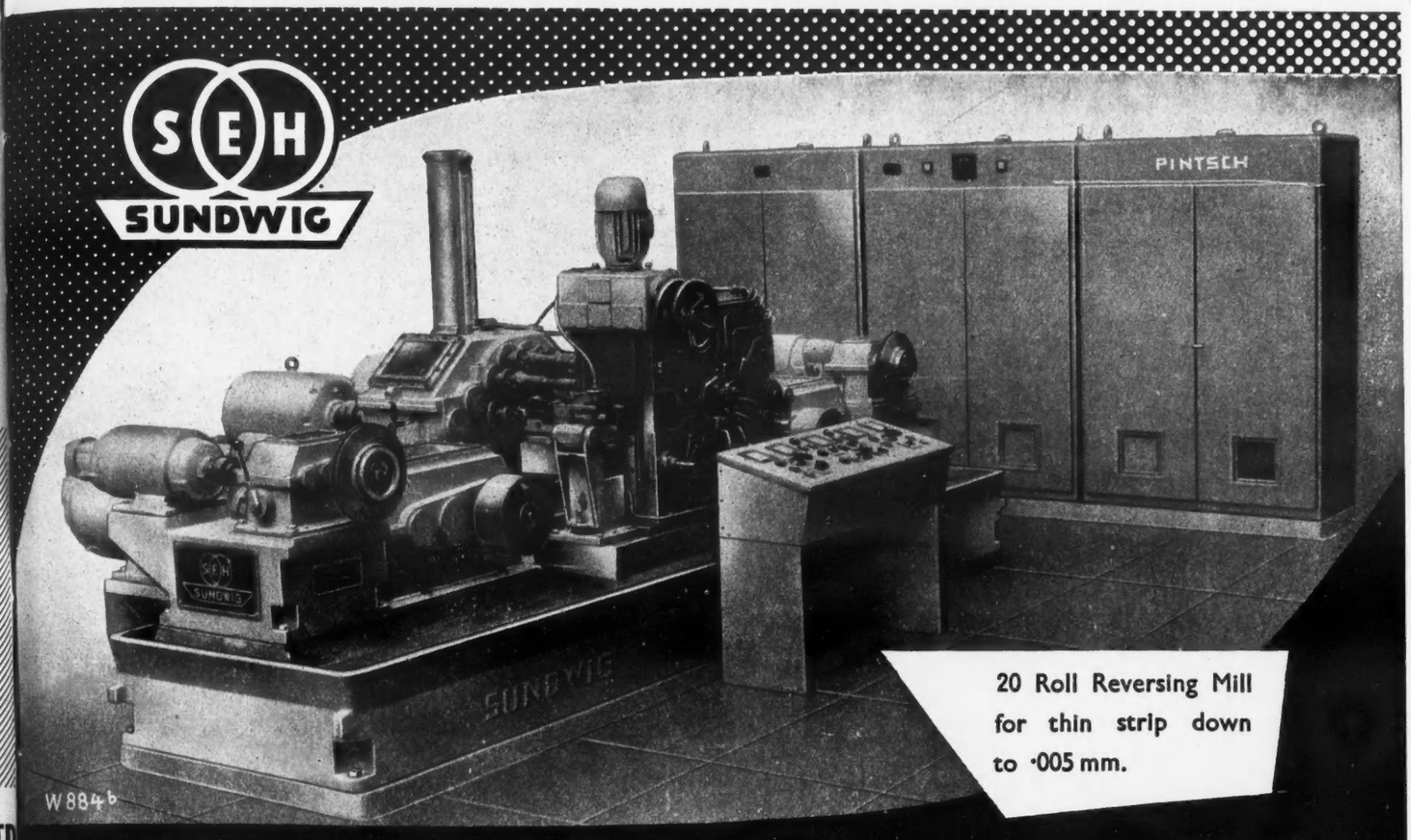

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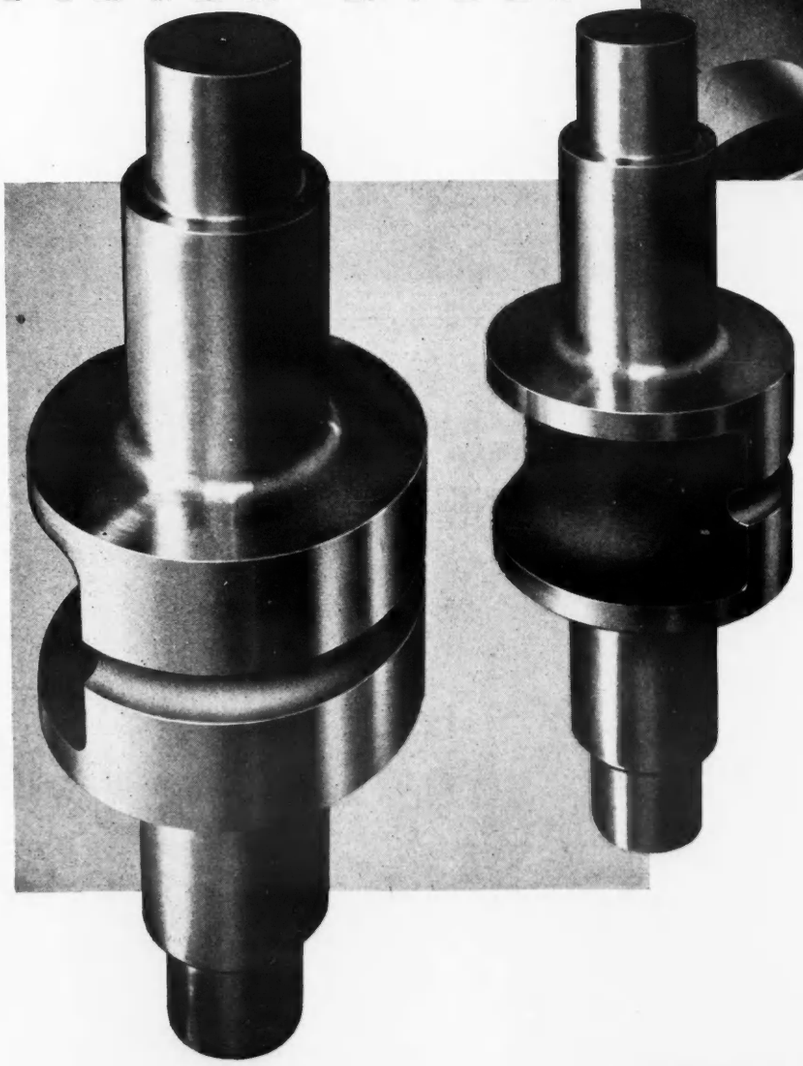

Evolved with great success to meet the specific case, Firth Brown FPRF Carbon Chromium Molybdenum Steel castings combine wear-hardness with the great shock-resistance needed for tube manufacture.

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CLASSIFIED ADVERTISEMENTS

PUBLIC APPOINTMENTS · SITUATIONS VACANT · TENDERS · EDUCATIONAL · BUSINESSES and PREMISES · BUSINESS OPPORTUNITIES PATENTS · MISCELLANEOUS · AGENCIES · DIRECTORS · PARTNERSHIPS

Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/-. **Inch Rate.** 54/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

FOR SALE · MACHINERY, etc., WANTED · AUCTION SALES · SITUATIONS WANTED · SUB-CONTRACTING · DESIGN SERVICES · FOR HIRE

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-. **Inch Rate.** 48/- per single column inch and pro rata. 12 lines to 1 inch.

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Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

NIGERIAN COLLEGE OF ARTS, SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING OF UNIVERSITY COLLEGE, IBADAN, AT NIGERIAN COLLEGE OF ARTS, SCIENCE AND TECHNOLOGY

CHAIR OF MECHANICAL ENGINEERING

Applications are invited for the CHAIR OF MECHANICAL ENGINEERING. Salary scale (contract) £3400 p.a., including contract and inducement addition. Equivalent of existing F.S.S.U. contributions or tax-free gratuity at £150 p.a. Free first class passages (up to a maximum of four adult passages) on appointment, termination and annual leave in U.K. Part-furnished quarters at low rental. Children's U.K. maintenance and other allowances. Appointments normally on contract for two sessions in first instance and renewable. Appointment on secondment may also be considered on the same terms. Detailed applications (8 copies) naming three referees as soon as possible to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained. E5708

JAMAICA COLLEGE OF ARTS, SCIENCE AND TECHNOLOGY

KINGSTON

Principal: H. FALKNER, M.Sc. (Wales), B.Sc. (Lond.), A.Inst.P.

SENIOR LECTURER

Applications are invited for appointment as SENIOR LECTURER in Mechanical Engineering. Salary scale: £1300 by £50 to £1550, but likely to be revised to £1500 by £50 to £1750.

Appointment will be made above the minimum according to qualifications and experience. Appointment may be either permanent or on contract. Possible Housing assistance. The College is a rapidly developing one.

Further information obtainable from Council for Overseas College, 12, Lincoln's Inn Fields, London, W.C.2, to whom applications (6 copies) giving age, qualifications, experience and names of 3 referees should be sent by 6th September, 1960. E5709

SURREY EDUCATION COMMITTEE

KINGSTON TECHNICAL COLLEGE, FASSETT ROAD, KINGSTON-UPON-THAMES

ASSISTANT LECTURER

Applications invited for post of ASSISTANT LECTURER Grade B for Production and Machine Shop Engineering for September 1960, or as soon as possible thereafter. Salary, Burnham Technical Scales, £700 by £27 10s. to £1150, plus London Allowance. Additional increments payable for approved industrial experience.

Further particulars and application form from Principal on receipt of stamped addressed envelope. E5662

CIVIL SERVICE COMMISSION

PATENT EXAMINERS AND PATENT OFFICERS

PATENT EXAMINERS AND PATENT OFFICERS. Pensionable posts for men or women for work on the examination of Patent applications. Age at least 21 and under 29 (36 for Examiners), with extension for regular Forces service and Overseas Civil Service. Qualifications: normally first or second class honours degree in physics, chemistry, engineering or mathematics, or equivalent attainment, or professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. London salary (men) £655 to £1460; provision for starting pay above minimum. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1., for application form, quoting S/128/60, and stating date of birth. E5670

PUBLIC APPOINTMENTS

CITY AND COUNTY OF KINGSTON UPON HULL

CITY ENGINEER'S DEPARTMENT

APPOINTMENT OF ELECTRICAL ENGINEERING ASSISTANT

Applications are invited for the appointment of an ELECTRICAL ENGINEERING ASSISTANT, A.P.T. Grade IV—£1065 to £1220 per annum, commencing salary according to experience. Preference will be given to applicants who are Associate Members of the Institution of Electrical Engineers or have passed the qualifying examinations.

Comprehensive experience in the design of electrical installations for public buildings, public utility works, or industrial plants is necessary.

The Department is responsible for a continuous programme of mechanical and electrical design and installation works including high tension sub-stations, heavy duty pumping plant, electrical generation, mechanical handling, refrigeration, refuse disposal plant, heating, ventilating and general engineering.

Some industrial experience is desirable, and previous Local Government service is not essential.

Housing accommodation will be made available for the successful married candidate not already resident within the City.

Consideration will be given to a contribution towards removal expenses.

Applications on forms which can be obtained from the City Engineer, Guildhall, Kingston upon Hull, are to be returned not later than the 9th September, 1960.

Wm. MORRIS, O.B.E.,
City Engineer.

Guildhall,
Kingston upon Hull. E5669

AIR MINISTRY

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary—£805 at 25 to £1095 at 34 or over, thereafter rising to maximum £1260 with increase for London and slight decrease for country districts. Appointments non-pensionable but long term. Promotion prospects. 5 day week with 4 weeks 2 days leave a year initially. Special allowance in addition to salary during overseas service. Qualifications and experience:

(i) (a) University degree or equivalent diploma in electrical and/or mechanical engineering with at least 2 years apprenticeship; or
(b) Graduate or corporate member of I.E.E. with at least 3 years apprenticeship; or
(c) Graduate or corporate member of I.Mech.E. appreciable electrical engineering experience with at least 3 years apprenticeship; and
(ii) Have been employed for minimum of 2 years with well established engineering concern and gained wide experience in both electrical and mechanical engineering practice.

Applicants must be natural born British subjects between ages of 25 and 45. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.158/OA. E5671

CITY OF NOTTINGHAM WATER DEPARTMENT

APPOINTMENT OF TWO GRADE APT V CIVIL ENGINEERING ASSISTANTS

Applications for the above permanent, pensionable appointments are invited from Engineering Graduates, and/or Corporate Members of the Institution of Civil Engineers with five years engineering experience, preferably with a Water Undertaking. The Department has in hand a varied programme of new works estimated to cost £1¼ millions, offering considerable opportunities for gaining valuable experience. Salary, dependent upon qualifications and experience, £1220 by £55 by £50 (2) to £1375.

Applications, with names of two persons to whom reference may be made, to Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, not later than 31st August, 1960.

T. J. OWEN,
Town Clerk.

The Guildhall,
Nottingham. E5699

PUBLIC APPOINTMENTS

STAFFORDSHIRE POTTERIES WATER BOARD

APPOINTMENT OF CIVIL ENGINEERING ASSISTANT

Applications are invited for the following appointment:

ONE CIVIL ENGINEERING ASSISTANT, Grade A.P.T. V (£1220 to £1375 p.a.). This appointment is not on the permanent staff but will be for not less than three years. Applicants must be Corporate Members of the Institution of Civil Engineers and have had experience in the design and construction of at least one of the following: Pumping stations, filtration plant, reinforced and mass concrete service reservoirs and aqueducts.

Free Housing accommodation will be provided and reasonable removal expenses paid by the board.

The appointment is subject to the provisions of the National Scheme of Conditions of Service; to the provisions of the Local Government Superannuation Act, 1937; to termination by one month's notice on either side; and to the successful candidate passing a medical examination.

The Board have considerable major works in hand which are to be completed within the next three to five years. These works include the development of an impounding reservoir scheme with the design and construction of pumping station, filtration plant, aqueducts up to 40in. diameter, and concrete service reservoirs up to 10 million gallons capacity.

Applications, stating age, full details of training, qualifications, present and previous appointments, details of experience, together with copies of two recent testimonials, or the names of two persons to whom reference can be made, should be forwarded to the undersigned not later than Monday, 5th September, 1960.

C. V. BROWN,
M.I.C.E., M.I.Mech.E., M.I.W.E.,
Engineer & Manager and Clerk.

Albion Street,
Hanley,
Stoke-on-Trent. E5713

MANCHESTER REGIONAL HOSPITAL BOARD

ENGINEERING CLERKS OF WORKS (ELECTRICAL AND MECHANICAL)

Manchester Regional Hospital Board invite applications for three posts of ENGINEERING CLERKS OF WORKS (ELECTRICAL AND MECHANICAL) in connection with the hospital capital building programme. Salary £800 by £40 (5) by £50 (1) to £1050. National Health Service conditions and superannuation. Application forms obtainable from the Secretary of the Board, Cheetwood Road, Manchester, 8, to whom they should be returned by 6th September, 1960. E5680

GOVERNMENT OF TANGANYIKA

FACTORY INSPECTOR

FACTORY INSPECTOR (male, aged 32 to 40) required to undertake, under general direction of Labour Commissioner, administration of legislation, organisation of factory inspection, training and supervision of Inspectors. B.Sc. (Engineering) degree or equivalent (e.g. A.M.I.Mech.E.) essential. Previous experience in administration of factories legislation or in industry as a Safety Engineer, desirable. Post on contract/resettlement grant terms. Salary scale £1194 to £1863 inclusive. Quarters at low rental. Free passages and medical attendance. Education allowance (in respect of children educated in secondary schools outside Tanganyika). Tour of service 30 to 36 months. Low income tax. Generous home leave. Further particulars and application forms from Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.132/8/01/04. Candidates should state their full names when applying. E5655

INSTITUTION OF GAS ENGINEERS

ASSISTANT SECRETARY

The Institution of Gas Engineers invites applications not later than 12th September, 1960, for the appointment of ASSISTANT SECRETARY at a commencing salary of £1750 per annum. Conditions from the Secretary, The Institution of Gas Engineers, 17, Grosvenor Crescent, London, S.W.1. E5462

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY GENERATING BOARD

STEAM TESTING DEPARTMENT —NORTH EASTERN DIVISION

SECOND ASSISTANT ENGINEER

Applications are invited for the appointment of a SECOND ASSISTANT ENGINEER in the Steam Testing Department with headquarters at Dunston-on-Tyne, to lead a small section carrying out thermal performance tests on modern steam plant.

Applicants should be corporate members of the Institution of Mechanical or Electrical Engineers, and should have had previous plant testing experience. A knowledge of power station operation will be considered an advantage.

The salary for the appointment will be in accordance with the National Joint Board Agreement, Schedule "B," Grade 5 (£1375 to £1610 per annum) and will commence at a point commensurate with qualifications and experience.

Forms of application may be obtained from any office of the Board or from the Assistant Regional Secretary (Personnel), Central Electricity Generating Board, North Eastern and Yorkshire Region, 1, Whitehall Road, Leeds, 1, to whom they should be returned to arrive not later than the 30th September, 1960. E5695

ARCHWAY GROUP HOSPITAL MANAGEMENT COMMITTEE

WHITTINGTON HOSPITAL, N.19

ASSISTANT ENGINEERS

TWO ASSISTANT ENGINEERS required at Whittington Hospital, N.19. Applicants over 25 years of age preferred who should have completed practical training in mechanical engineering. Ordinary National Certificates for Mechanical Engineering or equivalent an advantage. Salary scale £570 to £700 per annum plus £30 London Weighting at 26 or over. Successful candidates will be required to reside within reasonable distance of hospital. Department may be visited by direct appointment with Hospital Secretary, ARC: 3070 Ext: 254. Application forms obtainable from and returnable to Group Secretary, 46, Cholmeley Park N.6 within 10 days. E5660

COAL UTILISATION COUNCIL

DEPUTY PRINCIPAL

The Coal Utilisation Council is expanding yet again to cope with the many opportunities in the market for domestic solid fuel. We are a friendly and active non-commercial organisation. Hours are 9.30 to 5.30, Monday to Friday; 19 days holiday a year. Optional pension fund.

One of the people we are looking for, and the minimum commencing salary we have in mind is:

DEPUTY PRINCIPAL of the Council's Training Centre at Vauxhall, with good educational background, preferably in Science or Mechanical Engineering. He will be responsible for the daily supervision and administration of training courses. A good knowledge of domestic heating practice and ability to write technical reports important. Lecturing experience and organising ability essential. £1200.

Apply to C.U.C., 3 Upper Belgrave Street, S.W.1 (SLOane 9116) for an application form and fuller particulars. E5701

BRITISH SHIPBUILDING RESEARCH ASSOCIATION

VIBRATION INVESTIGATIONS

The British Shipbuilding Research Association requires a University graduate to take charge of a small section carrying out researches into ship machinery vibration problems. Previous experience in this field is essential and practical training would be an advantage. The starting salary, depending on age and qualifications will be in the range of £1000 to £1700 per annum. The position carries superannuation under F.S.S.U. Applications with full particulars should be addressed to: B.S.R.A., 5 Chesterfield Gardens, Curzon Street, London, W.1. E5704

Classified Advts. continued on page 100

PUBLIC APPOINTMENTS

TRINIDAD AND TOBAGO ELECTRICITY COMMISSION

VACANCIES FOR SHIFT CHARGE ENGINEERS

The Trinidad and Tobago Electricity Commission has vacancies for SHIFT CHARGE ENGINEERS.

Applicants should have experience in the operation of modern steam turbines, water tube boilers and diesel generators, and must have Graduate Membership of the I.E.E., or I.Mech.E., or Associate Membership of the I.Mar.E., or the Higher National Certificate in Electrical or Mechanical Engineering or Second Engineer's M.O.T. Diesel and Steam Certificate or Charge Certificate, Royal Navy.

The annual salary is £1408 rising by three annual increments to £1537. This salary includes a payment for Shift Work.

A partly furnished house will be provided at a rent of £10 8s. 4d. per month, plus a small extra charge for the heavy furniture.

An outfit allowance of £60 is paid on arrival in Trinidad.

First Class passage to Trinidad will be provided for the successful applicant, his wife and children up to a maximum cost of four adult passages. First Class leave passages to the United Kingdom will be provided every three years.

There is a Superannuation Scheme similar to the C.E.G.B. and Area Boards' Scheme.

Information on Trinidad can be obtained from the West Indian Committee, 40 Norfolk Street, London, W.C 2.

Applications giving full details of qualifications, age, experience, etc., together with copies of two recent testimonials should be sent by Air Mail to reach the General Manager, Trinidad and Tobago Electricity Commission, P.O. Box 121, Port-of-Spain, Trinidad, W.I., by 30th September, 1960. E5707

TYNE IMPROVEMENT COMMISSION

APPOINTMENT OF ASSISTANT ELECTRICAL ENGINEER

Applications are invited for the position o ASSISTANT ELECTRICAL ENGINEER, under the Commissioners' Electrical Engineer, in their Dock and Harbour Undertaking. The minimum qualification is the Higher National Certificate in Electrical Engineering and Membership of the Institution of Electrical Engineers with at least Student or Graduate status.

Applicants should have had experience in the maintenance and operation of A.C. and D.C. operated plant, control gear, substations and distribution systems, &c.

The commencing salary will be within the range £850 to £1300 per annum according to age and experience.

The post is superannuable and the successful applicant will be required to pass a medical examination and become a member of the Tyne Commission Superannuation Fund.

Applications stating age, qualifications and experience and giving the names of referees who can testify to the candidate's character and professional ability, should be sent to the undersigned in envelopes endorsed " Assistant Electrical Engineer " not later than 6th September, 1960.

R. N. EGGLETON,
Secretary.
Bewick Street,
Newcastle upon Tyne, 1. E5658

WEST PARK HOSPITAL

EPSOM, SURREY

ASSISTANT ENGINEER

ASSISTANT ENGINEER required. Salary (£670 to £810 per annum, plus London Weighting), and conditions of service are subject to National Health Service Regulations. The appointment is subject to satisfactory medical examination. The hospital accommodates 2000 patients suffering from mental illness.

The successful applicant will be required to reside in an unfurnished house on the estate for which a moderate rent will be charged.

Candidates must have completed an apprenticeship in mechanical engineering, or have otherwise acquired a sound practical training in mechanical engineering, and must hold one of the following, or equivalent qualifications :

Ministry of Transport and Civil Aviation Second Class Certificate of Competency in Marine Engineering or Certificate of Service as Second Class Engineer.

Ordinary National Certificate in Mechanical Engineering which includes Heat Engines as a subject and is endorsed in the Principles of Electricity.

Ordinary National Certificate in Electrical Engineering with endorsement in Applied Mechanics and Heat Engines.

Applications with full particulars, together with the names and addresses of three referees, should be sent to the Group Secretary by 31st August, 1960. E5698

WOLVERHAMPTON CORPORATION WATER UNDERTAKING

TWO ENGINEERING ASSISTANTS

Wolverhampton Corporation Water Undertaking requires TWO ENGINEERING ASSISTANTS for new works design and construction. Salary according to qualifications and experience, £1065 to £1220 (Grade APT IV) or £785 to £1070 (Special Grade). N.J.C. Service Conditions, 5-day week, house to rent. Post pensionable, medical examination. Applications, naming two referees, to Water Engineer and Manager, Water Offices, 37 Merridale Road, Wolverhampton, by August 29th 1960. E5623

PUBLIC APPOINTMENTS

BUILDING RESEARCH STATION (D.S.I.R.)

GARSTON, NR. WATFORD, HERTS

CIVIL OR MECHANICAL ENGINEERS AS SCIENTIFIC/SENIOR SCIENTIFIC OFFICERS

Building Research Station (D.S.I.R.), Garston, Nr. Watford, Herts, requires CIVIL OR MECHANICAL ENGINEERS as SCIENTIFIC/SENIOR SCIENTIFIC OFFICERS for investigations aimed at modernising building operations, increasing productivity and reducing cost by application of increased mechanisation, new methods of construction and improvement of current building processes. Work will ensure close contact with coming developments in buildings of all types. Qualifications : 1st or 2nd Class Honours degree in civil or mechanical engineering. For S.S.O. at least 3 years post-graduate experience and minimum age 26. Salary ranges (Men) S.O. £690 to £1144 ; S.S.O. £1250 to £1540. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1., quoting E.341/OA. Closing date 16 September, 1960. E5710

MINISTRY OF AVIATION H.Q.

LONDON

AERONAUTICAL ENGINEER/ MATHEMATICIAN

AERONAUTICAL ENGINEER/MATHEMATICIAN required at Ministry of Aviation Headquarters, London, for assessment of transport aircraft projects for commercial operations and R.A.F.; includes estimation of conventional, V.T.O.L. and supersonic transport aircraft performance and matching of this to routes and economies of operation. Appointment in grade of SENIOR SCIENTIFIC OFFICER (minimum age 26). First or second class honours degree in aeronautical engineering or mathematics (or equivalent) and at least 3 years post-graduate research experience required. Salary range £1330 to £1640 with superannuation under F.S.S.U. Possibility of establishment for those under 31. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A.366/OA. Closing date 15th September, 1960. E5696

MINISTRY OF AVIATION NATIONAL GAS TURBINE ESTAB.

PYESTOCK, HANTS

TECHNICIAN

Ministry of Aviation National Gas Turbine Establishment, Pyestock, Hants., requires TECHNICIAN to assist in technical direction and supervision of electronic light electrical and instrumentation work in connection with large engine test cells. Qualifications : Recognised engineering apprenticeship or equivalent training in an appropriate trade. Practical experience of instrumentation for trials and test work and preferably knowledge of gas turbine test bed practice. H.N.C., or equivalent. Salary : £1005 to £1220 (under review). Forms from Ministry of Labour, Technical & Scientific Register (K), 26 King Street, London, S.W.1, quoting D.547/OA. E5697

SOUTH AUSTRALIAN GOVERNMENT

APPOINTMENTS

Applications are invited for appointments in the following professions in the Government Service of South Australia :

	Salary ranges
ENGINEERS, CIVIL	£A1170 to £A1920
DRAUGHTSMEN, STRUCTURAL	£A1340 to £A1525

Commencing salaries within these ranges according to qualifications and experience.

First-class passages provided for selected applicants and families.

Good leave conditions (Recreation, Sick and Long Service).

Superannuation Fund available.

Houses on a rental basis provided.

Full information from :

Agent General for South Australia,
50 Strand,
London, W.C.2.
WHItehall 7471. E5692

BOROUGH OF SWINDON

SENIOR ASSISTANT ENGINEER A.P.T. IV (£1065 TO £1220)

Applications are invited for the above appointment in the Borough Engineer's Department. The Borough is expanding rapidly under the Town Development Act and the large capital works programme offers excellent opportunities of gaining practical experience in design and construction of a variety of civil engineering works.

Candidates should be qualified Civil and/or Municipal Engineers.

A Five-day week is in operation. Housing Accommodation will be offered to married candidates from other areas, and assistance towards removal expenses may be granted.

Applications on forms to be obtained from the Town Clerk, Civic Offices, Swindon, must be returned not later than Tuesday, 6th September, 1960. E5717

TENDERS

WEST CORNWALL WATER BOARD

DRIFT WATER SCHEME

CONTRACT NO. 5— LEHA AND CRYOR RESERVOIRS

The Board invite FIXED PRICE TENDERS from EXPERIENCED CONTRACTORS for the CONSTRUCTION of TWO CONCRETE SERVICE RESERVOIRS with capacities of 500,000 gallons and 150,000 gallons, on sites in West Cornwall.

The reservoirs are of similar design being rectangular in plan with normally reinforced concrete walls, columns and flat slab roof.

The General Conditions of Contract, Specification, Bill of Quantities and Form of Tender for this Contract, prepared by the Engineers, Herbert Lapworth Partners, 25, Victoria Street, Westminster, S.W.1, may be obtained from the UNDERSIGNED on or after Monday, 29th August, 1960, on receipt of a cheque for £5 made payable to the West Cornwall Water Board, which sum will be returned on receipt of a bona fide Tender.

Tenders, together with all documents received are to be enclosed in a sealed cover endorsed " Drift Water Scheme—Tender for Contract No. 5—Leha and Cryor Reservoirs," and addressed to the UNDER SIGNED and delivered not later than 10 a.m. on Monday, 26th September, 1960.

Only Tenders from firms experienced in this type of work will be considered.

The Board do not bind themselves to accept the lowest or any Tender.

E. O. WHEALE,
Clerk to the Board.
Municipal Buildings,
Penzance, Cornwall. E5694

LEE CONSERVANCY CATCHMENT BOARD

SADLERS MILL STREAM DIVERSION SCHEME

TENDERS are invited for the following works in the Boroughs of Edmonton and Enfield, in the County of Middlesex :

(a) Construction of about 600 linear yards of 5ft. 6in. diameter CULVERT in tunnel and about 275 linear yards of same in trench.

(b) Construction of about 325 linear yards of REINFORCED CONCRETE CULVERT of widths varying from 4ft. 6in. to 9ft. and height about 4ft., together with manholes and appurtenant works.

Copies of the Tendering documents may be obtained after 18th August, 1960, from the Board's Consulting Engineers, J. D. and D. M. Watson, MM.I.C.E., 67, Tufton Street, Westminster, S.W.1, upon payment of a deposit of Ten Guineas, which will be returned only on receipt of a bona fide Tender and return of all documents. Cheques should be made payable to The Lee Conservancy Catchment Board. The Board does not bind itself to accept the lowest or any Tender.

No Tender will be considered unless received in the envelope provided (with no mark indicating the sender), sealed, and delivered to the undersigned by noon on 19th September, 1960.

J. D. SPILLER,
Clerk of the Board.
The Lee Conservancy Catchment Board,
Brettenham House,
Lancaster Place,
Strand, W.C.2. E5700

INDIA SUPPLY MISSION

TENDER ENQUIRY NO. S.E.232

The Office of the India Supply Mission, 2536, Massachusetts Avenue, N.W., Washington 8, D.C., United States of America, invites TENDERS for the following :

TRADE ENQUIRY No. S.E.232

For the SUPPLY of :

	Nos.
1. COAL HAULERS, 20-25 tons, max. 30 m.p.h.	12
2. CRAWLER TRACTOR DOZERS, d.b.h.p. 160 min.	4
3. ROTARY COAL DRILLS, Crawler-mounted for 2¼in-4in. diameter by 20ft.-40ft. dpeth of holes	2
4. MOTOR GRADERS, min. 100 b.h.p.	3

Specifications, &c., relative to the above specification, can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 14s. 4d. per tender, and is not refundable.

Tenders are to be returned direct to India Supply Mission, 2536, Massachusetts Avenue, N.W., Washington 8, D.C., United States of America, so as to reach them by 23rd September, 1960.

Specimen copy of the above enquiry can be seen at Engineering Branch, India Store Department, Bromyard Avenue, Acton, W.3, under the following reference S.3319/60/NSC/ENG.2. E5657

INDIA SUPPLY MISSION

TENDER NOTICE NO. SE.223

The office of India Supply Mission, 2536 Massachussetts Avenue, N.W. Washington 8, D.C., United States of America, invites TENDERS for the following :

TENDER NOTICE No. SE.223

MOBILE WORKSHOP with Lathe, Drilling Machine and other Machine Tools, and complete with diesel Generator Set and full equipment for maintaining earthmoving equipment in the field.

Tender documents, &c., relative to the above, can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 14 shillings and threepence per Tender, and is not refundable. Tenders are to be returned direct to India Supply Mission, 2536, Massachussetts Avenue, N.W. Washington 8, D.C., United States of America, so as to reach them by the 21st September, 1960.

Specimen copy of the above enquiry can be seen at India Store Department, Vehicles Branch, Bromyard Avenue, Acton, W.3, under the following reference : S.3489/60/AKB/VEH. E5691

TENDERS

KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT, BANGKOK, THAILAND

INVITATION FOR BIDS—NO. YS 3-3

The Royal Irrigation Department of the Kingdom of Thailand hereby invites SEALED WRITTEN BIDS for FURNISHING and DELIVERING the following EQUIPMENT either f.o.b. Contractor's shipping point or c.i.f. Bangkok Wharf, Thailand, for the Bhumiphol Power Plant, Yanhee Multi-purpose Project, Kingdom of Thailand, in accordance with the Contract Documents, for :

Furnishing one (1) generator isolated-phase type bus structure, and two (2) each generator switchgear assembly including generator protective equipment, generator neutral grounding equipment cubicles, and one (1) double-ended station service unit substation.

Invitation for Bids will be issued in August, 1960, and will be opened in October, 1960. Copies of Contract Documents, Invitation for Bids—Nos. YS-3-3, Generator Bus, Switchgear, Protective Equipment, Neutral Grounding Equipment and Station Service Unit Substation, may be obtained by qualified Bidders on written request to : Royal Irrigation Department, Attention : Thai Liaison Engineer, c/o Engineering Consultants, Inc., 1901 South Navajo Street, Denver 23, Colorado.

Each request must be accompanied by a cheque or money order, payable to the Royal Irrigation Department, in the amount of U.S. $25.00 for each copy of the Contract Documents requested. The remittance is non-returnable.

M. L. XUJATI KAMBHU,
Director General.
Royal Irrigation Department,
Kingdom of Thailand,
Bangkok, Thailand. E5646

EDUCATIONAL

A.M.I.MECH.E., B.SC., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page, prospectus, free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114

U.K.A.E.A.

Harwell Reactor School

Standard Course No. 22

The next course will be held from 2nd January to 28th April, 1961, inclusive. The fee for the course is £250 exclusive of accommodation.

It is intended primarily for engineers and physicists whose main interest is in reactor design.

Control and Instrumentation of Reactors Course No. 6

This course will be held at Durley Hall, Bournemouth, from the 30th January to 10th February, 1961, inclusive. The fee for the course will be £52 10s. exclusive of accommodation.

It is intended for those who have a direct interest in the control and instrumentation of nuclear reactors, and it is assumed that participants have some knowledge of the basic principles of these subjects.

Senior Technical Executives' Course No. 12

The course will be held from 8th to 19th May, 1961, inclusive, of which the first week will be at The Reactor School, Harwell, and the second at Durley Hall, Bournemouth. The fee for the course is £52 10s. exclusive of accommodation.

This is an appreciation course for senior executives and gives the background to nuclear engineering.

Application forms and further details for these courses can be obtained from :

The Manager,
Reactor School,
A.E.R.E.,
Harwell,
Berks.

E5715

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

BRITISH OXYGEN RESEARCH AND DEVELOPMENT LTD. have a vacancy for an ENGINEER to carry out research and development work on pumps and pumping problems at low temperatures.—Please write to The Secretary, British Oxygen Research and Development Ltd., Deer Park Road, London, S.W.19. E5660

BOOKS AND PUBLICATIONS

STEAM TURBINE THEORY AND PRACTICE

By WILLIAM J. KEARTON, D.Eng. Seventh Edition

Continued developments in the science and art of steam turbine engineering have made further revision and enlargement of this standard work an absolute necessity. For the seventh edition new chapters have been added on Vortex Flow in Steam Turbines. The section dealing with examples of land and marine turbines has been revised and extended, and includes descriptions of turbines used in recent Naval construction, and turbines used for Nuclear Power Stations. Written primarily for the engineering student this book will prove of value to the engineer and draughtsman. Price 57s. 6d. net.

STEAM TURBINE OPERATION

By William J. KEARTON, D.Eng., M.I.Mech.E., etc. Sixth Edition

The use of higher initial steam pressures and temperatures to improve thermal efficiency of steam turbines has made careful handling of plant on starting and stopping of increased importance. In the latest edition of this standard work, full details of the modern supervisory control gear and protective equipment have been given and will be of assistance to all concerned with the operation of valuable plant. Price 35s. net.

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Winning Coal deals thoroughly with all methods of coal production at the face—it covers opencast production, deals concisely with the older hand-worked methods of mining and dwells at some length on the different methods of mechanized mining. A section of the book deals with the use of explosives and their substitutes for winning coal. The book has been designed to meet the needs of National and Higher National Certificate and Diploma students, those taking degrees in Mining at the Universities and candidates for the Associate-Membership examination of the Institution of Mining Engineers. Price 60s. net.

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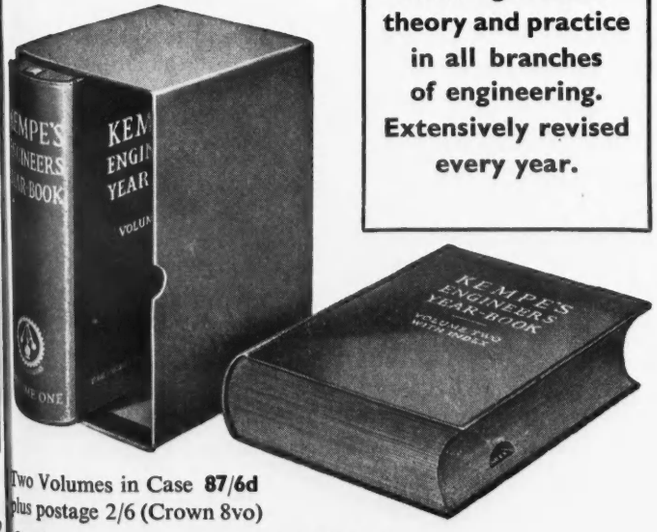

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SITUATIONS VACANT

DESIGNER DRAUGHTSMAN required for progressive Structural Engineering Co. in South London : excellent prospects for right man. Contributing Pension Scheme.—Write giving particulars and salary required.—BOX No. E2974, "The Engineer." A

DEVELOPMENT ENGINEER required for the Diesel Engineering Division of the Rootes Group with experience of high speed diesel engine development. Educational standard must be up to H.N.C. minimum and preferably higher. Applicants should be capable of dealing with all phases of diesel engine development.—Apply, with full particulars and salary required to The Secretary, Tilling-Stevens Ltd., (A Rootes Group Company), Victoria Works, Maidstone, Kent. E5679 A

DRAUGHTSMEN

required for the Diesel Engineering Division of the Rootes Group :

(a) Senior Draughtsman with experience of high-speed diesel engines. Initiative essential for this appointment.

(b) Draughtsman with experience of high-speed diesel engines for design and detail work.

In both cases applicants must be up to H.N.C. standard of technical education.

Apply, with full particulars and salary required to The Secretary, Tilling-Stevens Ltd. (A Rootes Group Company), Victoria Works, Maidstone, Kent.

E5678 A

DRAUGHTSMAN DESIGNER required for Equipment Department (responsible for new layouts, &c., in various parts of Fort Dunlop factory.) The work covers mechanical handling and/or design of automatic and semi-automatic machinery for rubber processing and tyre manufacture. (Rubber experience not essential but applicants should know something about mechanical handling and/or special-purpose machine design in other industries.) Holiday arrangements respected. Pension scheme ; five-day week ; excellent working conditions. Age range : 25-43.—Please write, giving brief details and commencing salary required, to Staff Officer (Reference E), Employment Department, Fort Dunlop, Erdington, Birmingham, 24. E5641 A

ENGINEER to take charge of site investigations and soil mechanics laboratory required by Consulting Engineers in Westminster. Excellent opportunity for well qualified, energetic man to secure pensionable post.—BOX No. E5586, "The Engineer." A

ENGINEERS, DRAUGHTSMEN, and all Technical staff, are invited to forward details of qualifications, etc., to Abbatt Technical Division, who will handle and negotiate on their behalf, without charge, any change of employment contemplated. Leading Organisations consult Abbatt, 25, Kensington High Street, W.8. WES. 0768-9. E2962 A

ENGINEERING INSURANCE. Applications are invited from Mechanical Engineers not over 35 years of age, who having served an apprenticeship with Crane and Lift Makers have a sound theoretical and practical knowledge of Cranes, Lifts, Lifting Machines and their maintenance, and are qualified to Higher National Certificate Standard, for a vacancy as ENGINEER SURVEYOR based in the Stoke-on-Trent district. The position is permanent, pensionable, with salary scale of £800 rising to £1100 per annum, plus expenses and allowances. —Apply in own handwriting to BOX No. E5664, "The Engineer." A

FISONS FERTILIZERS LIMITED need the services of experienced DRAUGHTSMEN who preferably have spent some time working in the Chemical Industry. The persons appointed to fill these vacancies should possess O.N.C.—preferably H.N.C. as the work involved requires detailed knowledge of modern machinery. Problems affecting both design and maintenance are part of the job. Working conditions are good. Staff amenities are comprehensive. Help with housing can be given for persons willing to move to this part of the East Coast which offers attractions to lovers of both coast and countryside.—Applications giving present position and salary, previous experience and employers, and educational qualifications should be sent to : Works Manager, FISONS FERTILIZERS LIMITED, Immingham, Grimsby, Lincs. E5677 A

FORENSIC ENGINEERS invite application from ENGINEERING GRADUATES with good background and industrial experience for responsible and individualistic post. Age not over 35.—BOX No. E5643, "The Engineer." A

MACHINE SHOP SUPERINTENDENT required for a well-known Diesel & General Engineering Works. Must be a first class practical Machine Shop man, tactful and used to leadership with drive and ambition. Used to piece-work, batch work and one-off jobs. Machines vary from small capstan to large boring, planing and milling machines.—Apply to BOX No. E5712, "The Engineer," stating age and experience. A

MECHANICAL, ELECTRICAL AND CIVIL ENGINEERS required by North Eastern engineering office dealing with industrial power plants and electrification schemes. The applicants, who should be aged between 28 and 35 years, should be keen and able to work with minimum supervision. Minimum qualification is H.N.C., together with good experience in Thermal Plant/Electrical design layout and the ability to handle Contract work. Contributory Superannuation Scheme.—Reply, giving full details of age, experience and present salary to BOX No. E5674, "The Engineer." A

MECHANICAL ENGINEERING DRAUGHTSMAN required by John Smith's Tadcaster Brewery Co. Ltd., The Brewery, Tadcaster, Yorkshire. Of good general education, and of H.N.C. or higher standard, and sound practical apprenticeship in a modern engineering works. At least two years Drawing Office experience essential, preferably on food, chemical or allied plant, pipe work, pumps, vessels and steam utilisation. Applicants must be able to pass medical examination and be of active and energetic character. Good starting salary with annual increments if satisfactory. Voluntary pension scheme in operation, canteen and sports facilities. Reply to Chief Engineer, stating age and qualifications, education, apprenticeship, and positions held, in chronological order. Expenses will be paid to those selected for interview. E5656 A

OPERATION EFFICIENCY ENGINEER required by the Power Services Department of Kodak Limited to analyse daily performance sheets, to plan the economic combination of plant and to carry out efficiency and acceptance tests. Candidates, who should hold H.N.C. or equivalent, must have a sound knowledge of thermal dynamics and operational experience of high and low pressure water tube boilers, pass out and back pressure turbines, large refrigeration plants, A.C. & D.C. electrical generation. The Company has approximately 5500 employees at its Harrow factory and runs non-contributory pension and sickness plans and a part contributory life insurance scheme.—Please apply : Men's Personnel Department, Kodak Limited (Factories), Wealdstone, Harrow, Middlesex. E5711 A

PUBLICITY ASSISTANT

required by

BRUCE PEEBLES & CO LIMITED, EAST PILTON, EDINBURGH, 5.

Applicants should have experience in technical journalism and ability to write lucid descriptions of engineering products and processes for publicity, press and other purposes, and be conversant with advertisement layout. The successful applicant would be required to write for, and edit, a Works magazine.

The Company manufacture heavy electrical plant and industrial electronic equipment and experience in those fields would be an advantage.

Full details, in confidence, of age, education, training, experience and salary required to Mr. J. S. Baillie, Publicity Manager, at above address.

E5652 A

REED BROTHERS (ENGINEERING) LTD.

Senior and Junior Draughtsmen required for varied and interesting design work on Medium and Heavy Hydraulic Press Projects. Experienced men preferred but applicants with good general engineering background considered. Excellent working conditions with Pension Scheme and Luncheon Vouchers.—Write Personnel Manager, Replant Works, Woolwich Industrial Estate, London, S.E.18.

E5703 A

SENIOR ASSISTANT EDITOR required by the Institution of Civil Engineers, responsible for the editing and make-up, with editorial assistance, of monthly engineering journal. Permanent appointment with good prospects to a man with engineering background. Starting salary between £870 and £1320 depending upon age and experience.—Apply : The Secretary, Institution of Civil Engineers, Great George Street, London, S.W.1. E5659 A

SITE CONSTRUCTION ENGINEER required in the age group 30-50 years. Several years' experience of site work essential, particularly with respect to the handling of both skilled and unskilled labour. The work will involve both civil and mechanical engineering and the applicant should have some drawing office experience so that he can read construction drawings and keep to erection programmes. The work will be in the Widnes area and will involve the supervision of the construction of chemical plants. The starting salary will be based on age and experience.—Applicants should write in confidence, giving details of experience, to Project Engineer, Forestal Land, Timber & Railways Company Ltd., Ditton, near Widnes, Lancs. E5640 A

STRUCTURAL STEELWORK DESIGNER required conversant with modern welded construction and B.S.S.449. Salary commensurate with experience and qualifications. First class prospects for the right man.—Apply to : G. R. Turner Limited, Langley Mill, Nottingham. E2977 A

TECHNICAL ASSISTANT for small Steel Rolling Plant near Birmingham. Age 22 to 30. Drawing Office experience essential.—Full details to BOX No. E2975, "The Engineer." A

TECHNICAL AUTHOR required, not over 45, to assume responsibility for the compilation of operating and maintenance instruction manuals dealing with the Company's machinery. This interesting and progressive pensionable staff position would appeal to a suitably qualified Mechanical Engineer with a bias towards technical writing.—Applications should be addressed to the Personnel Manager, Molins Machine Co. Ltd., Evelyn Street, London, S.E.8. E5590 A

THE BOWATER ORGANISATION

Applications are invited from men under the age of 45 years for the following vacancies which will shortly arise in our modern Power Plant.

DEPUTY POWER ENGINEER. Applicants must be capable of the technical supervision of a modern high pressure boiler plant and should have had technical training up to Institution standard followed by at least five years practical experience in a responsible position in the operation of a modern boiler plant including oil burning equipment.

ASSISTANT SHIFT POWER ENGINEER. Applicants should have technical training to Ordinary National Certificate level with practical experience in the operation of a modern high pressure boiler plant and oil burning equipment.

Applications giving details of age, training and experience should be addressed to the Mill Manager, Bowaters United Kingdom Pulp and Paper Mills Limited, Thames Division, Northfleet, Kent.

E5714 A

WORKS MANAGER required for Agricultural Engineering Works in East Anglia. Must have knowledge of Batch Production of Machines and Management of Men. Staff now about 40. Housing accomodation available. Salary according to qualifications and experience.—Reply in confidence giving Age, Qualifications and Experience to BOX No. E5467, "The Engineer." A

Classified Advts. continued on page 102

SITUATIONS VACANT

THE DISTILLERS COMPANY LIMITED

MECHANICAL ENGINEER (STANDARDS)

The Company has the above vacancy in its Engineering Division at Devonshire House in the West End of London. Candidates will be required to prepare engineering standards for chemical and other process industries, and should therefore have had experience in such work. Preference will be given to candidates who are Associate Members of the Institute of Mechanical Engineers. Age range 25-40. Working conditions are excellent, and the Company runs a non-contributory pension scheme and other fringe benefits.

Write :
STAFF MANAGER,
THE DISTILLERS COMPANY LIMITED
21-22 BOLTON STREET
LONDON, W.1.

Quote Ref : 83/60 T.E.

E5647 A

YOUNG MECHANICAL ENGINEER, preferably with Hydraulic experience required to assist Director with technical sales. Attractive permanent position; good prospects. Modern Works, London, S.E.18.—Write, stating qualifications and experience to H.E.R., BOX No. E5702, " The Engineer." A

SITUATIONS VACANT

DRAUGHTSMEN

Draughtsmen are required at the Midlands Research Station, Solihull.

The duties are interesting and will include work on the design of pilot and prototype plant associated with the development of new high-pressure processes for the production of town gas.

Candidates should possess at least an O.N.C. certificate in Mechanical Engineering.

The salary for the appointments, which are pensionable and subject to medical examination will be within the range of £770-£1015 per annum.

Applications, stating age, education and experience, should be addressed to the Industrial Relations Officer,

WEST MIDLANDS GAS BOARD,
6, Augustus Road, Edgbaston, Birmingham, 15

E190 A

SITUATIONS VACANT

GIRDLESTONE PUMPS LIMITED
require at their
WOODBRIDGE WORKS
a
DRAUGHTSMAN
WITH GOOD CENTRIFUGAL PUMP EXPERIENCE

This vacancy offers excellent prospects to a keen and intelligent young man wishing to join a progressive firm located in a pleasant residential area.

Good terms of employment with non-contributory Pension and Life Assurance benefits.

The expenses incurred by candidates selected for interview will be refunded. Local interviews can be arranged.

Applications with full details of educational background, age and experience by 31st August, to The Secretary,

GIRDLESTONE PUMPS LIMITED,
WOODBRIDGE, SUFFOLK.

E5706 A

SITUATIONS VACANT

APC

GROUP LEADER - STRUCTURES

A Leader is required at the Company's Laboratories at Heston, Middlesex for a team engaged on experimental stress analysis of large reactor structures and vessels and on the development of reactor components. Applicants should have an engineering degree and several years' appropriate experience in development work.

Applications giving full details of experience and qualifications should be sent to :

The Personnel Manager (Ref. E/128),
The Atomic Power Constructions Limited,
P.O. Box 90,
28 Theobalds Road, W.C.1.

E5673 A

DUBAI ELECTRICITY COMPANY
TRUCIAL STATES
PERSIAN GULF

APPOINTMENT OF CHIEF ENGINEER AND MANAGER

Applications are invited by the Dubai Electricity Company, Trucial States, for the position of Chief Engineer and Manager. Candidates should be qualified in Electrical Engineering and hold Membership of at least one of the Corporate Institutions, together with managerial and administrative experience. Commencing salary Rs 2,500 per month tax free and free furnished accommodation. Tours would be of two years' duration followed by three months' home leave. Air passages provided for wife and up to two children once in each contract period.

Applications, stating date of birth, qualifications and experience, together with names of three Referees, should be addressed to Reference R.F.S., Kennedy & Donkin, 12 Caxton Street, London, S.W.1., to arrive not later than September 16th, 1960.

E5606 A

Project Engineer

(INDIA)

PROJECT ENGINEER required by well known British Company of Engineering Contractors engaged on the building of heavy engineering plant. Applicants must have civil and/or mechanical engineering qualifications and experience of site construction is desirable. Preference will be given to applicants aged 25/40 who are qualified civil engineers with experience of plant erection. If required married accommodation will be available in Calcutta but the successful applicant must be prepared to travel to any contract in India. Good salary and bonus will be paid. Pension scheme is in operation. Tour of duty will be for three years initally with liberal leave. Send full details of training, qualifications and experience in strictest confidence to BOX No. E5587, " The Engineer." A

PLANT MANAGER

required by the Civil Engineering Dept. of

THE CLEVELAND BRIDGE & ENGINEERING CO., LTD.
Darlington, Co. Durham.

He should be between 30 and 50 years of age, with a long and wide experience of civil engineering plant and considerable administrative ability. Applications, giving qualifications and experience to the Chief Civil Engineer.

E5716 A

'ENGLISH ELECTRIC'

LIAISON ENGINEERS FOR NUCLEAR POWER STATIONS

The ENGLISH ELECTRIC COMPANY, Whetstone near Leicester invite enquiries from mechanical and electrical engineers to undertake varied and interesting liaison work in connection with the construction of Nuclear Power Stations in the following capacities :—

1. SITE LIAISON ENGINEER

   The Engineer concerned will be required to keep in close touch with site work so that he may be aware of all their problems and help resolve them with the appropriate department at H.Q.

   Practical experience such as obtained by Site Staff, Ships Engineers or Engineering Apprentices is necessary and experience in a large drawing, design or contracting office would be advantageous.

2. H.Q. LIAISON ENGINEER

   The Engineer concerned would be responsible for inter-departmental liaison and the preparation of reports to Management at the highest levels. He must therefore be able to write clear, concise reports and discuss projects with all levels of staff.

   Previous experience of liaison work in a large drawing/design contracting organisation will enhance applicants' prospects.

Both these appointments require technical qualifications to at least H.N.C. level.

The successful applicants will be attached to the Construction Department and located at Whetstone where assistance will be given with initial accommodation.

Enquiries giving details of age, experience, qualifications and current salary (which will be treated in strictest confidence) should be addressed to:—

The Technical Staff Officer, Marconi House (Dept. G.P.S.,) 336/7 Strand, London, W.C.2., quoting reference E1888D.

E5649 A

SITUATIONS VACANT

NORTHERN ALUMINIUM CO. LTD.
BANBURY

require an ENGINEER aged 26/32 to undertake design and development work in the Engineering Section of the Sales Development Division. The post, which involves a variety of interesting projects, calls for technical competence and initiative, and candidates should preferably have some knowledge of design in and fabrication of aluminium. A good engineering background and academic qualifications of university degree standard essential.

Write giving full details of education, experience, etc. to :—

Personnel Officer,
Northern Aluminium Co., Ltd.,
Bush House, Aldwych, London, W.C.2.

E5648 A

SITUATIONS VACANT

CHIEF ENGINEER

Required for large non-ferrous foundry in Midlands. Must have experience of all types pneumatic, hydraulic and electric equipment. Capable of organising for preventive maintenance.

Please write in confidence giving full details to :

Managing Director,
BIRMID INDUSTRIES LIMITED,
Dartmouth Road,
Smethwick, 40, Staffs.

E2966 A

SITUATIONS VACANT

WORKS MANAGER

G. & J. KITCAT LTD., Publishers' Bookbinders, London, propose to appoint a Works Manager who will be responsible for production. The bindery is highly mechanised, hence analogous to light engineering. It is hoped to find a man who will be ready to accept wider responsibilities in a few years' time.

Candidates must have first-class experience in works management and production planing ; a knowledge of bindery machines and processes, though desirable, is not essential. The most appropriate age is between 35 and 45.

The salary will be commensurate with the qualifications required ; there is a contributory pension scheme with life insurance.

Applications, which will be treated in confidence, should be addressed to the Secretary (Bindery), 14 Welbeck Street, London, W.1.

E5668 A

SITUATIONS VACANT

DESIGNERS

required for

STRUCTURAL DESIGN DEPARTMENT. Several years' experience in steelwork design in heavy industrial structures, bunkers, gantries, etc., essential. Applicants must be qualified with H.N.C. And/or A.M.I. Struct.E. The work is varied and interesting and there are good prospects. 5-day week, 3 weeks' holiday, luncheon vouchers and pension scheme. Write giving full particulars to

STAFF DEPT.,
HUNTINGTON, HEBERLEIN & CO., LTD.
28-29, Dover Street, London, W.1.

E5666 A

Chief Engineer

A large oil storage installation on the Thames requires a Chief Engineer to take control of its Engineering Department.

Applicants must be of good education and have an Engineering Degree (preferably B.Sc. in Mechanical Engineering), together with long term practical experience in the handling of men, plant maintenance, budgetary control and administration.

The salary offered is attractive and applicants between the ages of 40-50 would be preferred. The company operates a contributory Pension Scheme, with Life Assurance.

Write, giving full details of education, qualifications and past experience, to:

The Managing Director,
London and Thames Haven Oil Wharves Ltd.,
Bucklersbury House,
83, Cannon Street, London, E.C.4.

E5705 A

ENGINEERING STAFF TRAINING OFFICER

required by

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

to take charge of the training of professional and ancillary grades within the Engineering Division and to supervise the training schemes for Technical Assistants and Graduate Apprentices. The work involves liaison with industry regarding the latter's training and lecturing on engineering topics.

Applicants should be corporate members of a senior engineering institution and preferably have an engineering honours degree. They should have had industrial experience and some teaching or training experience is desirable.

SALARY : £1370 — £1825 p.a.

Housing and superannuation schemes.

Please send POSTCARD for details to Personnel Manager (1766/25), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

E5667 A

Unilever | CEYLON

ASSISTANT ENGINEER
COLOMBO

Ceylonese nationals, who are qualified mechanical or electrical engineers, are invited to apply for the post of Assistant Engineer in Unilever's company in Ceylon.

Candidates should be under 30.

The man selected will be able to look forward to a progressive management career, and starting salary will be in line with the opportunities offered. Initial training will be given in this country.

Applications should be addressed to:

PERSONNEL DIVISION (T322),
UNILEVER HOUSE, BLACKFRIARS, LONDON, E.C.4.

E5651 A

THE NUCLEAR POWER GROUP

requires

DESIGN ENGINEERS

With the contract for Dungeness Nuclear Power Station, The Nuclear Power Group is now actively engaged upon the construction of four major Nuclear Power Stations as well as designs for new plants in the United Kingdom and Overseas.

Applications are invited from suitably qualified men for the following appointments.

1. SENIOR ENGINEER—To be responsible for the design and development of burst fuel element detection systems. Experience in this field is desirable, but not essential.
2. SENIOR ENGINEER—For the design of special reactor components, remote handling equipment and special mechanisms.

Applicants should be between 28 and 35 years of age and should hold a degree and be corporate members of the Institution of Electrical or Mechanical Engineers.

The positions will be tenable at the Group's offices situated in their own grounds at Knutsford, Cheshire.

Housing assistance will be given to married men.

Applications, giving details of age, qualifications, and experience, should be addressed to :

The Personnel Manager,
The Nuclear Power Group,
Radbroke Hall,
Knutsford,
Cheshire.

Quoting reference : TE/ELEC/6.

E5675 A

Classified Advts. continued on page 104

SITUATIONS VACANT

DRAUGHTSMEN

required for expansion programme by old-established Yorkshire Company, and preferably having specialised experience in one or more of the following subjects—transmissions, hydraulics, electric motors, switchgear. These are permanent positions in modern offices with a progressive Company. Applications should state age, experience, technical qualifications and salary expected.—Write Box E.493, c/o Streets, 110 Old Broad Street, E.C.2.

E5645 A

DESIGN DRAUGHTSMAN

Thomas Morson & Son Ltd., require a design draughtsman for work on chemical plant design, layouts, piping work etc., Candidates who should have a H.N.C. in mechanical engineering or equivalent will be expected to deal with a wide variety of the problems met in project engineering. Salary not less than £1000 p.a. depending on experience and qualifications.

Apply Engineering Director, Thomas Morson & Son Ltd., Wharf Road, Ponders End, Enfield, Middlesex.

E2972 A

WORK STUDY ENGINEERS

are invited to apply for vacancies that offer temporary engagements, at advantageous terms of 1 to 2 years duration, in a light Engineering factory situated in the Midlands.

The project involved is of importance and concerns review, re-study and implementation of Company Policy in the appl[illegible]ion o[illegible] Work Study affecting several thousand employees.

Permanent posts will be availa[illegible]le to some participants on [illegible]ompletion of this project.

Applicants should write, quoting EG/M, stating age, qualifications and experience to The Personnel Manager, BOX No. E5593, "The Engineer." A

Braby DRAUGHTSMAN

required for Structural Section with experience in detailing of framed buildings, hoppers and supporting steelwork. Site measuring experience essential. O.N.C. with Structural endorsement. Preferably over 25 years of age.

Good salary and working conditions. Staff pension scheme.

Apply to :

THE PERSONNEL MANAGER,
FREDK. BRABY & CO. LTD.,
THAMES ROAD, CRAYFORD, KENT.
(CRAYFORD 26262)

E5665 A

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SALES BY AUCTION

		Main Location	*Auctioneers*
September 1	**Vehicles, machine tools and miscellaneous stores** including :—	**M.A.O. Storage Depot, Bowhouse, Hurlford, Nr. Kilmarnock, Ayrshire.**	**DIXON & WALLACE, LTD.** (Dept. L), Bank Buildings, Graham Square, Glasgow, E.1. (Tel.: Bridgeton 2447/9).
	Motorcycles; saloon cars; utilities; vans; trucks; trailers, diesel road rollers; Priestman excavators; Ransome & Rapier crane. Lathes; shaping machines; rammers; hand tools; tool kits; M.T. spares; plumbing equipment and spares including domestic boilers; water storage cisterns and cylinders. Electrical spares; canteen and kitchen equipment; furniture; crockery; cutlery; bedding; rugs; carpets; clothing including berets; shorts; buttons; old canvas; webbing; groundsheets; containers; etc.		
September 6-7	**Machine tools and miscellaneous stores.**	**M.O.A. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18.**	**FULLER, HORSEY, SONS & CASSELL,** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861).
September 13	**Miscellaneous stores.**	**No. 1 E.S.D., Long Marston, Nr. Stratford-on-Avon, Warwicks.** (Sale at the Hippodrome, Stratford-on-Avon).	**LOCKE & ENGLAND,** (Dept. L), 166, Parade, Leamington Spa, Warwicks. (Tel.: 2833).
September 16	**Miscellaneous stores.**	**M.O.A. Storage Depot, Rotherwas, Hereford.**	**RUSSELL, BALDWIN & BRIGHT, LTD.** (Dept. L), 20, King Street, Hereford. (Tel.: 4366).
September 21	**Machine tools and miscellaneous stores.**	**Technical Stores Depot, Old Dalby, Leics.** (Sale at Melton Mowbray.)	**SHOULER & SON,** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 3081).
September 27-30	**Vehicles, motor cycles, earth moving and lifting equipment.**	**M.O.A. Storage Depot, Ruddington, Notts.**	**WALKER, WALTON & HANSON,** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel. 54272).

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E118 A

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NICKEL ALLOY STEELS

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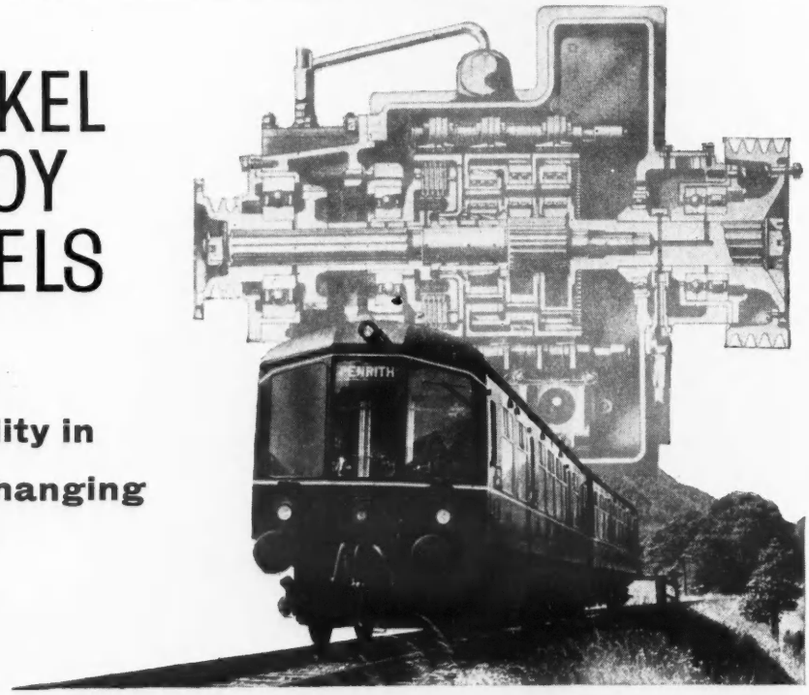

THE self-changing gear box, produced by Self-Changing Gear Box Ltd., Coventry, is standard on road, rail and water transport in many lands, and notably on London's buses.

This famous unit, in both its pre-selector and fully automatic versions, incorporates a range of nickel alloy steels. Although there is no direct mechanical operation of the gears in the normal way, heavy train, truck and bus operation inevitably imposes severe stresses upon the gears and to withstand these stresses most of the operating mechanism in the 'Wilson' box is made from nickel alloy steels, including the 3 per cent nickel-chromium-molybdenum EN 36 case-hardening steel.

TYPICAL CORE MECHANICAL PROPERTIES OF

EN36

SIZE	HEAT TREATMENT	MAXIMUM STRESS t.s.i.	ELONGATION per cent	IZOD ft. lb.
1¼" dia.	Oil quenched 780°C.	72·0	19	69
2⅛" dia.	Oil quenched 860°C. Oil quenched 780°C.	62·7	19	67
3" dia.	Oil quenched 860°C. Oil quenched 780°C	59·7	22	72

The benefits to be gained from the more highly alloyed case-hardening nickel steels, such as EN 33, EN 34, EN 36 and EN 39 include ease of heat-treatment, minimisation of processing distortion, and general reliability.

Please send for our publications entitled, 'The Mechanical Properties of Nickel Alloy Steels' and 'The Case Hardening of Nickel Alloy Steels'

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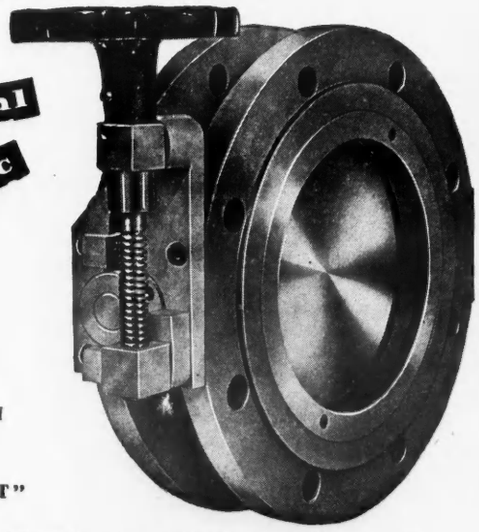

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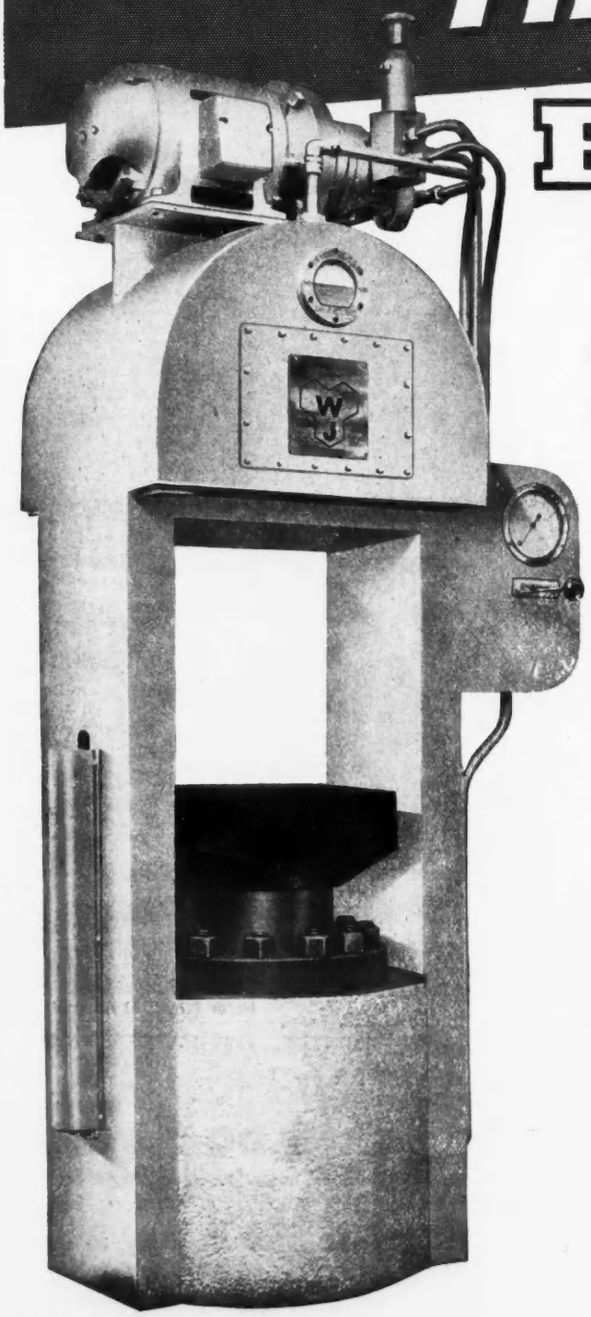

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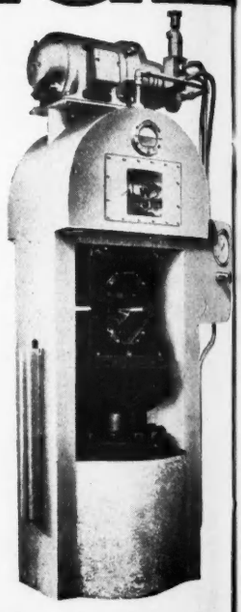

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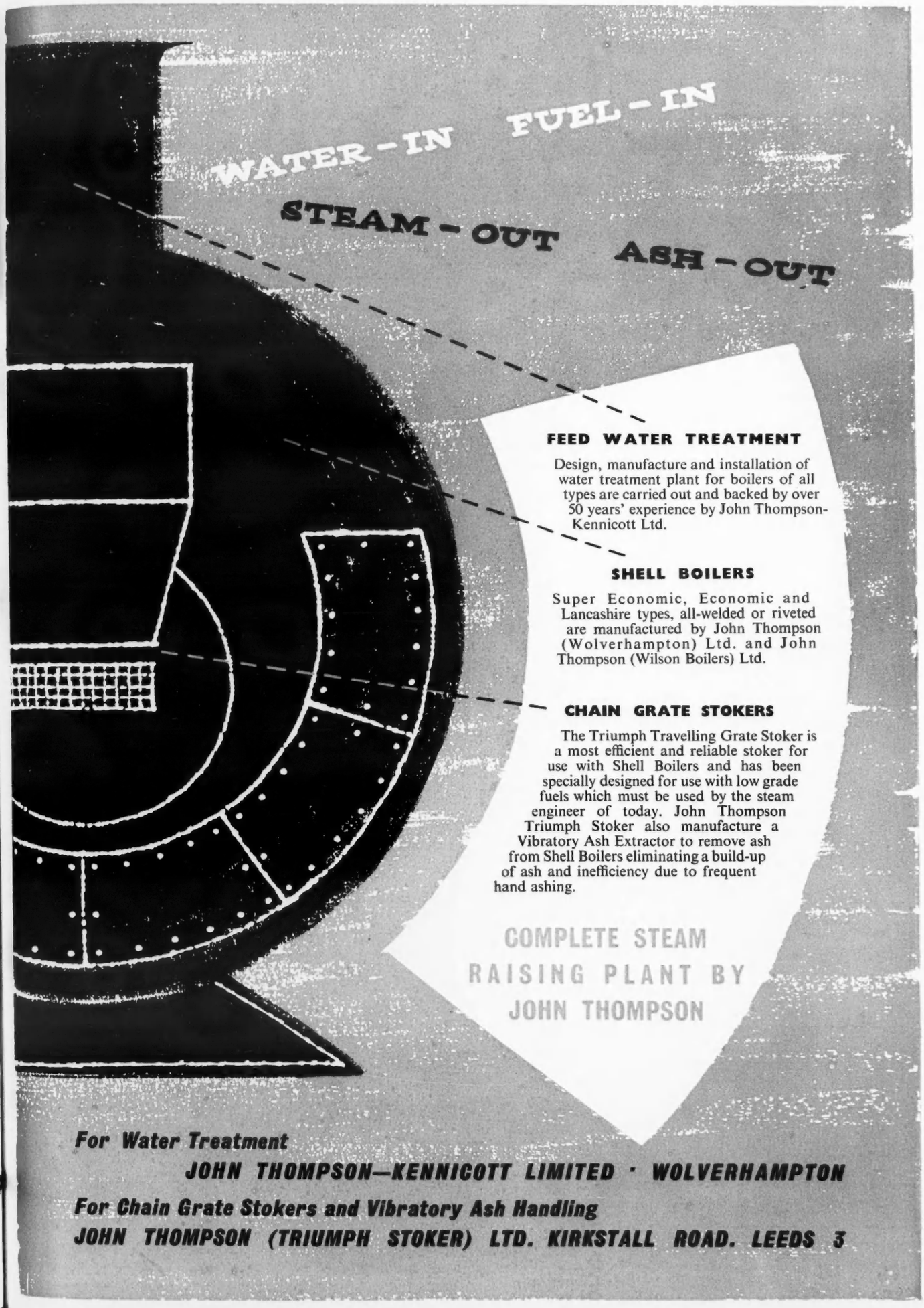

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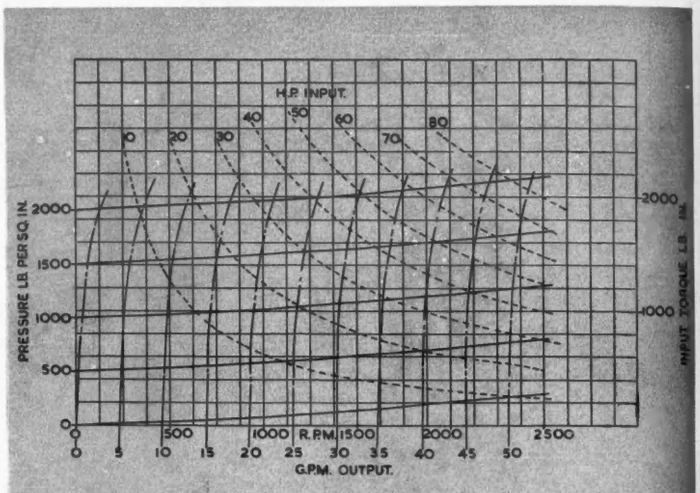

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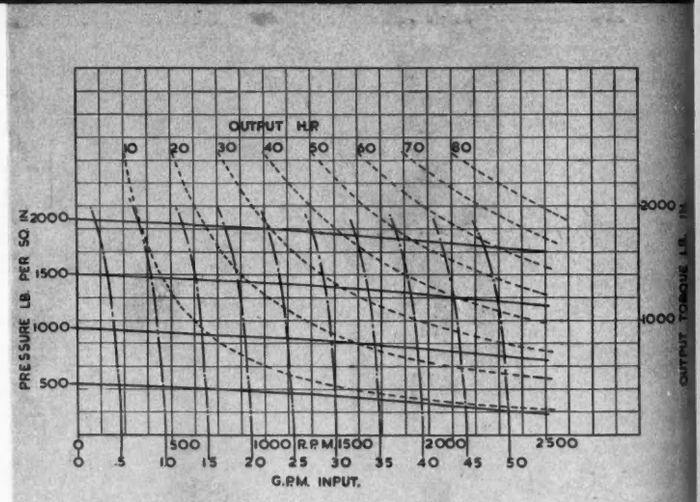

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